HAM TIPS

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144-Megacycle Transmitter

72-Watts Input on 144 Mc with an RCA-5894

By R. M. Mendelson,* W2OKO

The appearance of a new tube often prompts the adventurous ham to re-appraise his equipment with a critical eye. W2OKO looked over the specifications for the new RCA-5894, a high-efficiency version of the 829, and found it was time he built an up-to-date 144-Mc rig. The result is a transmitter that takes advantage of the best features of this high-frequency twin beam power tube. Ready for 72 watts of modulated input, the circuit described below incorporates stable VFO tuning, broad-band multipliers for a minimum of tuning controls, a high-efficiency tank circuit, and coaxial output with antenna switching.

Since attention to wiring and construction detail often spells the difference between R3 and R5 at 144 Mc, more than usual "how-to" information will be supplied for this rig. The transmitter will be described in two parts. Part I contains a description of the set, the circuit diagram and parts list, and advice on wiring and construction for those who want to get off to an early start. Adjustment and operation will be described in Part II.

The RCA-5894, a twin beam power tube designed to operate at frequencies up to 400 or 500 Mc, offers many advantages in a modern 144-Mc rig. Since a survey of recent literature disclosed little information on how to capitalize on the tube's possibilities, the transmitter described in this article was developed.

The VFO and multiplier tubes are all well-known ham types. A 5894 is used for the final stage; this tube has balanced structure with low interelectrode capacitances and low cathode inductance. The 5894 is internally neutralized, eliminating all need for external neutralizing circuits. These features, plus the 5894's low rf losses and high power sensitivity, make it an excellent choice for operation with a full 'phone input of 72 watts at 144 Mc.

The complete schematic diagram is shown in Figure 3. The VFO operates in the 8-Mc range, using a 6AU6 in a conventional Clapp oscillator and feeding into a 5763 buffer stage. A 5763 multiplier stage triples to 24 Mc. By means of switch S_1, this stage may also be used as a crystal oscillator for scheduled contacts, net operations, etc. A second 5763 multiplier doubles to 48 Mc to feed a pair of 5763's in a push-pull tripler that drives the final.

The buffer and the two single-tube multi-

* RCA Tube Division, Harrison, N. J.

pliers use slug-tuned coils in self-resonant plate circuits. When the coils are peaked for 146-Mc operation, they give adequate drive from 144 to 148 Mc. The push-pull tripler, capacitively coupled to the final, also provides ample, well-balanced drive over the entire band. Screen-voltage divider R_{17} controls the amount of drive, while R_{18} prevents accidental lowering of drive below a safe value.

To prevent a parasitic oscillation in the final, it was necessary to use a series-tuned screen bypass circuit formed by C_{29} and the internal tube screen-lead inductance. R_{21} serves a dual purpose. First, it acts as a screen-voltage dropping resistor. Since it is wire-wound, however, it also serves as an rf choke at 144 Mc. Its location is important and is discussed under "Construction."

The efficiency of the final circuit stems from the 5894 and from its tank design. This type of design was described in *Electronics,* May, 1947 (p. 130), and sample calculations were given for 144 Mc. Referring to Figure 6, note that the basic circuit is a pair of parallel lines surrounded by a large copper shield. The parallel lines terminate in a copper disk. Separated from this disk by a mica insulator is another copper disk which forms the "bottom" of the shield. The shield prevents radiation from the tank lines and raises the circuit Q considerably.

Loading is varied, and output is taken by means of a movable hairpin loop coupled to the shorted end of the tank. As can be seen from Figure 3, the shield disk and mica insulation also act as an rf bypass capacitor (C_{32}) for this end of the tank line. Dimensions of the components are fairly critical. The parts can be machined easily, however. They can also be made with hand tools if proper care is exercised. Details are included under "Construction."

Because of the push-pull operation, it is essential that the plate circuits of the 5894 be balanced if both plates are to run cool. Since a balanced antenna coupling is indicated, the hairpin loop should not be used to couple directly to a coaxial line. To make the coupling, a conventional antenna tuner cut for 144 Mc (*QST*, January, 1952, p. 50) is used in reverse. For feeding 50-ohm coaxial line, the input taps on the coil will be approximately one-half turn in from each end; however, they are best located experimentally—as described under "Operation."

Transmitter Layout

As shown in the panel layout, tuning controls are necessary only for the last multiplier plate and the final plate, and are located just below the grid-current and plate-current meters. From left to right across the bottom row are the final excitation control, the crystal-VFO selector, crystal sockets, the filament switch, and antenna loading and tuning controls. Filament and high-voltage pilots and a fuse holder complete the lower level. The VFO tuning knob, calibration dial, and band-set adjuster are in the upper right corner of the panel.

The rig is built on a 17″ x 13″ x 3″ steel chassis bolted to a 19″ x 8 ¾″ steel panel. Because of the frequency multiplication of 18 times from VFO to final, it is best for good stability to use steel here and provide strong panel-to-chassis bolting.

Figure 1. Panel view of the 144-Mc transmitter. VFO bandset control is directly above the center of the VFO dial.

The VFO and buffer stages are mounted on the left side of a steel box behind the right end of the panel. The first two multiplier stages are on the left of the chassis toward the front. The tripler-driver is located back of the doubler, on a sub-chassis and in line with the socket of the final tube. This arrangement allows short coupling leads to the final. Its symmetry also helps to keep the final grid circuit balanced. The 5894 is mounted horizontally, allowing easy connection to the plate tank circuit and adequate ventilation around the tube. This method also keeps heat from getting to the tuned lines where it might affect tuning stability. Tripler and final tuning controls are brought to panel mounts by simple pulley arrangements, as shown in Figure 5.

Antenna link coupling is made at the cold end of the tank lines and is carried by two feed-through bushings below the chassis to the antenna tuner.

The voltage-regulator tube for VFO plate and screen voltage is at the back of the chassis. On the chassis back wall are the antenna and receiver coax connectors and the power input plug.

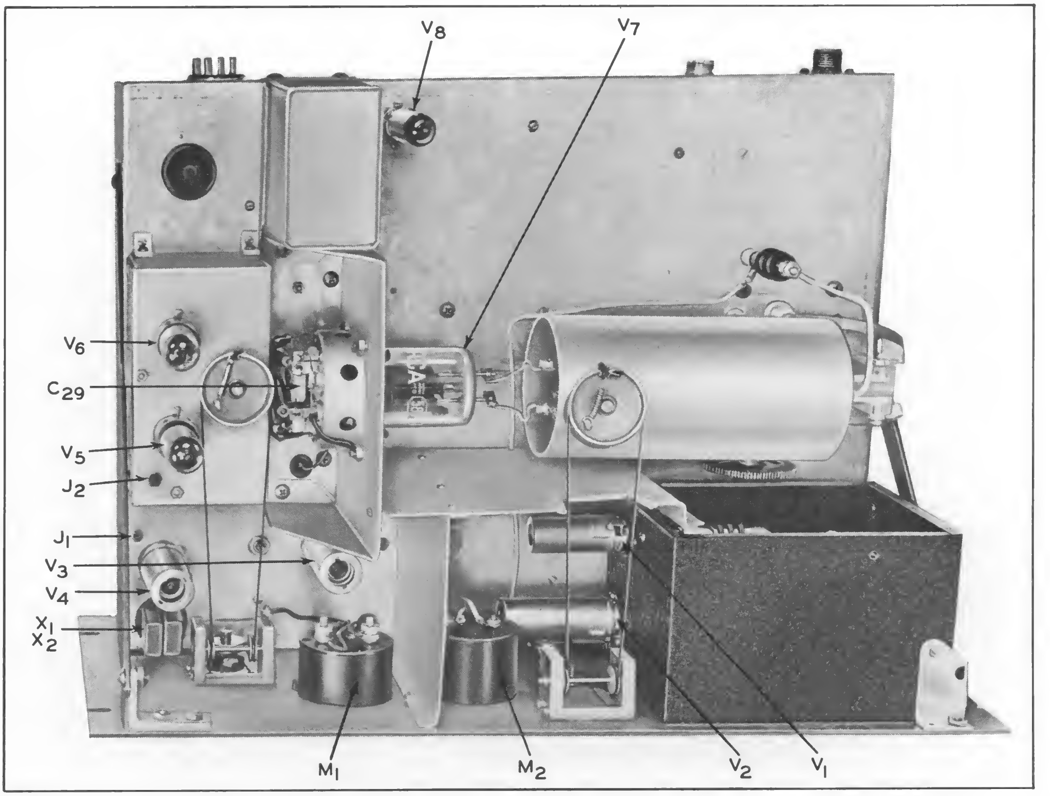
Construction

If the usual precautions against feedback are observed, no difficulties should be encountered in the construction of this transmitter. Keep all rf leads as short as possible. Only dc and filament leads may be cabled; even on these, adequate rf bypassing should be used close to the tube sockets.

The VFO box is held to the panel with 12 screws. It has no rigid connection to the chassis. Added strength is provided by the use of 12 more screws to fasten the back plate to the box. Heat from the tubes is dissipated outside the box, because only the cold components and the rf tuned circuit are placed inside. Note that a bus-bar is used for all VFO and buffer ground connections. The bus-bar is grounded to the chassis only at the tuning capacitor rotor (C_2). Design of this sort has proved valuable in obtaining a steady VFO frequency. (See VFO described in HAM TIPS, December, 1953.)

The VFO coil is made of 2″ B & W coil stock, chosen for strength and high Q. The

Figure 2. Top view. Note expansion loops in plate leads of the RCA-5894. The two pulley assemblies can also be seen.



coil is best mounted by gluing to a piece of Lucite, using any good plastic cement between the Lucite and the coil's plastic frame. This larger Lucite piece may then be bolted to the front panel on 1″ porcelain standoffs. Keep the coil as far as possible from the cabinet walls. The tuning capacitor, which should be of the two-bearing type, is also bolted to the front panel. In this way the lead from coil to condenser is kept short; more important, the capacitor and coil are kept rigid with respect to each other.

To insure good shielding, paint should be scraped from the back of the panel where the VFO box makes contact. Similarly, scrape the paint from the area of contact between the box and its back cover.

Wiring of the multipliers up to the push-pull tripler requires no comment except to repeat the advisability of shoft rf leads.

Link coupling is used to the grids of the tripler because of its location. Feed-through bushings fix link coil L_6 and allow the tripler sub-chassis to be lowered into place after both the sub-chassis and socket wiring for the final have been completed.

Filament, plate, and screen leads from the sub-chassis are fed through a grommet and wired later to their proper points under the chassis. The grid coil is broad-tuned and is adjusted when the transmitter is put into operation. For reduced lead inductance, it is advisable to use 5⁄16″-wide copper ribbon for the plate-to-tank leads. The use of tube shields on this stage is not recommended since the loss of rf power through the added plate-ground capacitance will be excessive.

In wiring the final socket (which should contain ventilating holes and be shielded and sunken), note that the screen lead and grid return are fed through the chassis by bushings. Copper ribbon is used from the screen to its feed-through. The screen bypass trimmer should be mounted across the socket to the point at which the heater and cathode are grounded. Place it at a slight tilt so that it may be tuned from above. Under the chassis, the screen dropping resistor is mounted directly on the feed-through bushing and is bypassed by a high-voltage mica capacitor (C_{30}) at the B + end. The grid-

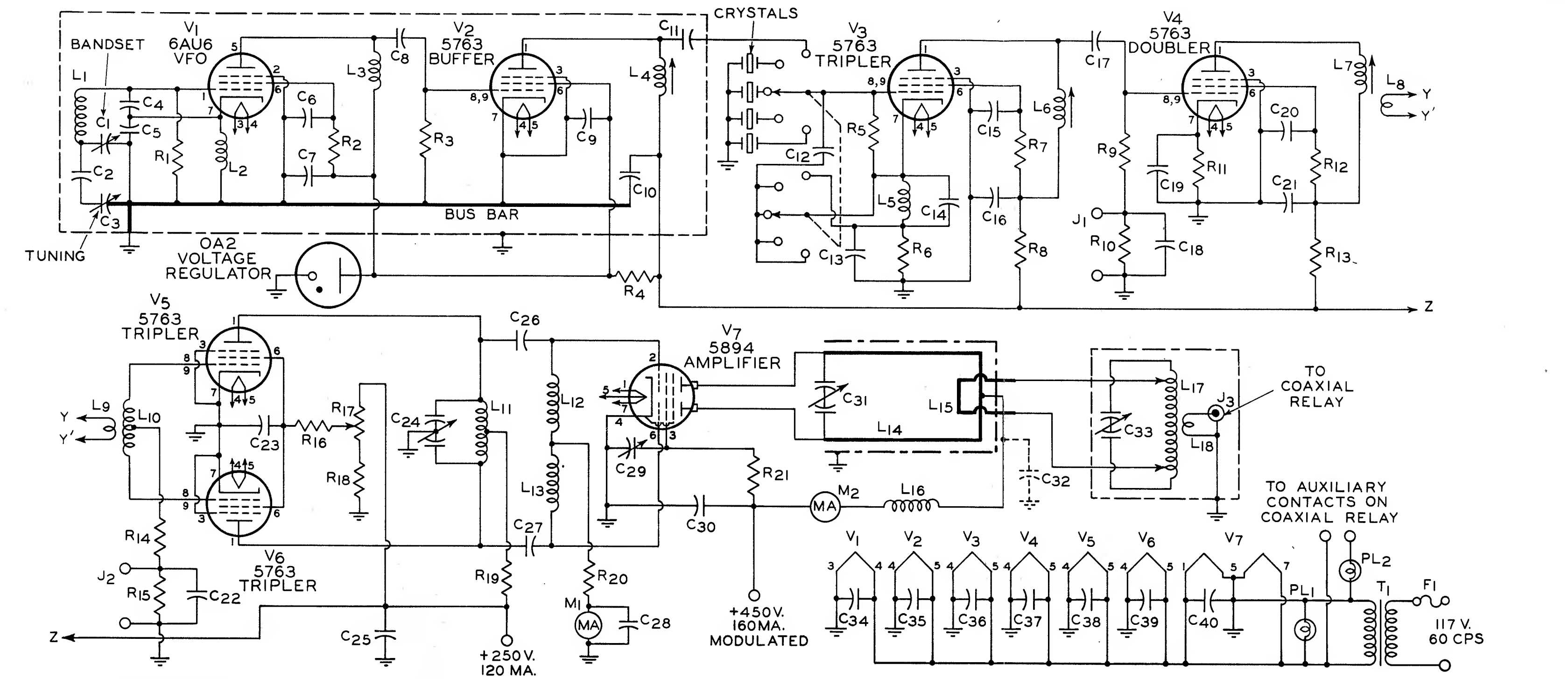


Figure 3. Schematic diagram and parts list.

C_1	50 $\mu\mu$f variable (Hammarlund APC-50)
C_2	5 $\mu\mu$f ceramic, zero temp. coeff. (Erie NPOK-050)
C_3	15 $\mu\mu$f variable, dual bearing (National SEU-15)
$C_{4,5}$	500 $\mu\mu$f silver mica (El-Menco CM15-E501J)
$C_{6,7,9,10,13,15,}$ $C_{16,34,35,36,40}$	0.01 μf ceramic (Centralab CRL D6-103)
$C_{8,17}$	50 $\mu\mu$f ceramic (Erie GP1K-500)
C_{11}	100 $\mu\mu$f ceramic (Erie GP1K-101)
C_{12}	10 $\mu\mu$f ceramic (Erie GP1K-100)
C_{14}	150 $\mu\mu$f ceramic (Centralab CRL D6-151)
$C_{18,19,20,21,22,23}$ $C_{28,37,38,39,41}$	0.001 μf ceramic (Centralab CRL D6-102)
$C_{24,31}$	10 $\mu\mu$f per section butterfly (Hammarlund BFC-12)
C_{25}	2 μf oil, 600 WVDC (Cornell Dubilier TJU 6020)
$C_{26,27}$	20 $\mu\mu$f ceramic (Erie GP1K-200)
C_{29}	7-45 $\mu\mu$f variable ceramic disk (Erie TS2A-7)
C_{30}	0.002 μf mica, 2500 WVDC (Cornell Dubilier Type 9L)
C_{32}	See text
C_{33}	15 $\mu\mu$f per section variable (Hammarlund HFD 15X)
F_1	Fuse, 3AG, 1 amp.
$J_{1,2}$	Insulated phone tip jacks
J_3	Output jack to coaxial relay
L_1	20 turns #16, 2″ diam., 2″ long (B&W 3907 coil stock)
$L_{2,3}$	RFC, 2.5 mh, 125 ma (National R-100U)
L_4	23 turns #26 enam., ½″ diam., close-wound (on slug-tuned coil form National XR-50)
L_5	RFC, 2.5 mh, 125 ma (National R-100)
L_6	7 turns #26 enam., close-wound on same type form as L_4
L_7	4 turns #26 enam., close-wound on same type form as L_4
L_8	2 turns #16 enam., coupled to L_7
L_9	1 turn #16 enam., ¾″ diam.
L_{10}	20 turns #16 enam., ½″ diam., spaced wire diam., plus ¼″ space at center for L_9
L_{11}	2 turns #16 bare, ½″ diam., spaced ⅛″
$L_{12,13}$	RFC, 1.8 μh (Ohmite Z144)
$L_{14,15}$	See text
L_{16}	RFC, 2.5 mh, 300 ma (National R-300ST)
L_{17}	5 turns #16 bare, ⅝″ diam., spaced ⅛″
L_{18}	1 turn #16 bare, ¾″ diam.
M_1	Meter, 0-15 ma
M_2	Meter, 0-500 ma
$PL_{1,2}$	6-8 v, #40 or #47 pilot lights
R_1	47,000 ohms, 1 watt
$R_{2,8,13}$	1,000 ohms, 1 watt
R_3	50,000 ohms, ½ watt
R_4	3,000 ohms, 10 watts
R_5	68,000 ohms, ½ watt
$R_{6,11}$	330 ohms, ½ watt
$R_{7,12}$	12,000 ohms, 1 watt
R_9	82,000 ohms, ½ watt
$R_{10,15}$	1,000 ohms, ½ watt
R_{14}	33,000 ohms, ½ watt
R_{16}	8,000 ohms, 1 watt
R_{17}	20,000 ohms, wire-wound variable, 2 watts
R_{18}	20,000 ohms, 2 watts
R_{19}	100 ohms, 1 watt
R_{20}	10,000 ohms, 1 watt
R_{21}	15,000 ohms, wire-wound, 20 watts
S_1	DP 5-position ceramic rotary switch (Centralab 2505)
T_1	6.3 v, 10 amp (Stancor P6308)

Miscellaneous

Chassis	17″ x 13″ x 3″ steel (ParMetal B-4536 or C-4536)
Panel	19″ x 8¾″ x ⅛″ steel (ParMetal 6604 or G6604)
Sub-chassis	5″ x 3″ x 2″ (Open-side half of Flexi-mount ICA-29341, or bend from aluminum stock)
VFO shield box	6″ x 5″ x 4″ steel (ICA-3812)
Ant. tuner box	4″ x 4″ x 2″ aluminum (ICA-29810)
Coaxial relay	(Advance CB/1C2C/115VA)

Note: Manufacturer's names and part numbers are given only to identify components used in this transmitter. Equivalent components by other manufacturers may be substituted wherever desired.

bias resistor is mounted between its feed-through and a stand-off, from which a lead runs to the grid meter. Again, 5/16″ flexible copper ribbon, having a U-bend to take up thermal expansion, is used for plate-to-tank leads. This construction prevents the plate-terminal seals from being subjected to any strain.

The shields shown in the top views of the chassis keep any final rf away from earlier stages. They also separate the final grid and plate meters. These shields were installed during the design trouble-shooting of the rig but may not be necessary.

Depending on available facilities, some ingenuity may be required to build the final tank. The disks may be cut easily if a drill press and fly cutter are used; if not, a hack saw and file will do an acceptable job. The copper shield tubing may be obtained from any large plumbing-supply house. If the dimensions shown are used, the tank will be right on frequency.

In this tank, a spacer of laminated mica and fiber glass was used. Regular mica may be substituted, however. The thickness should be at least 1/16″ to prevent arc-over but is not critical otherwise. Teflon sheet of at least the same thickness also may be used. Teflon was used here to hold the antenna coupling loop in alignment. Lucite may also prove satisfactory. In any event, these fittings should be kept snug to hold their setting.

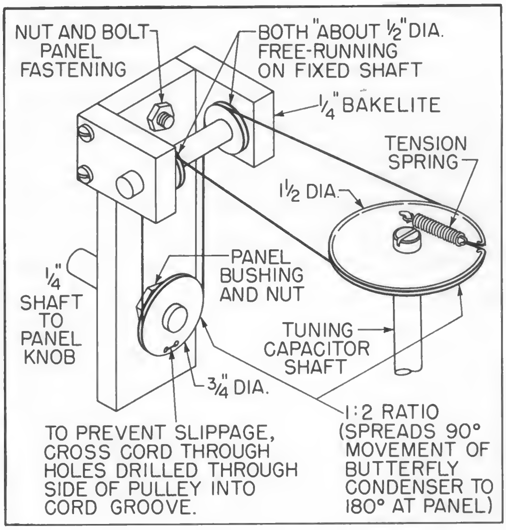
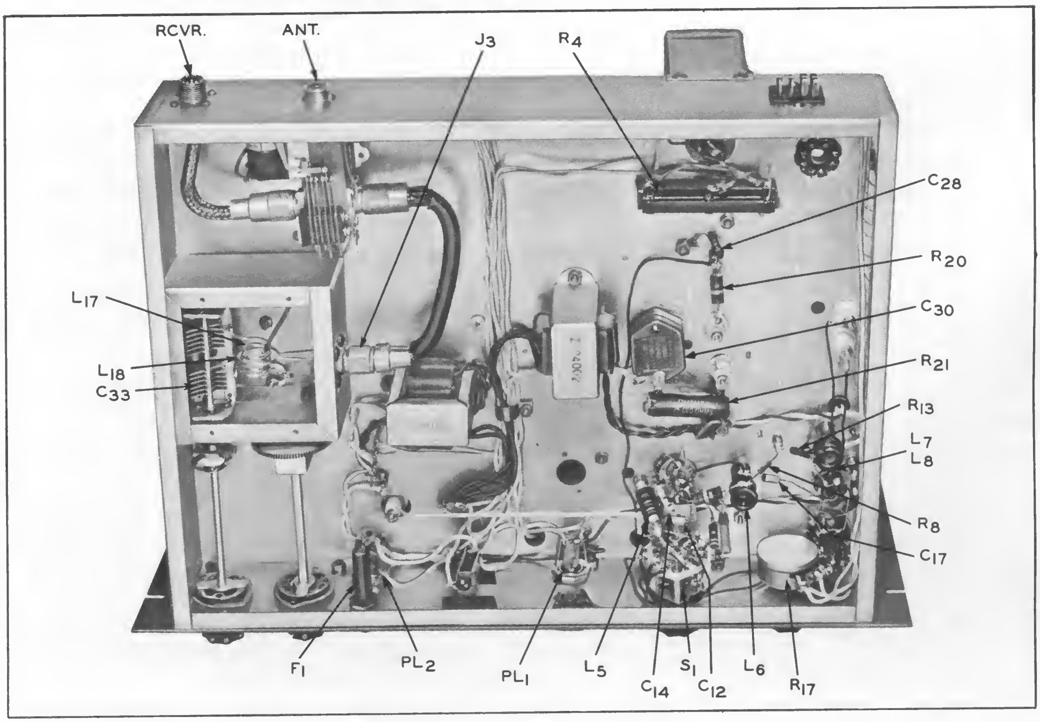


Figure 5. Suggested construction for the two pulley drives.

In the transmitter shown, a mechanical linkage is used to vary the antenna loading. This linkage was put in before final design was reached and proved to be an unnecessary refinement. Once set, the link will

Figure 4. Bottom view, showing arrangement of components for shortest rf leads.



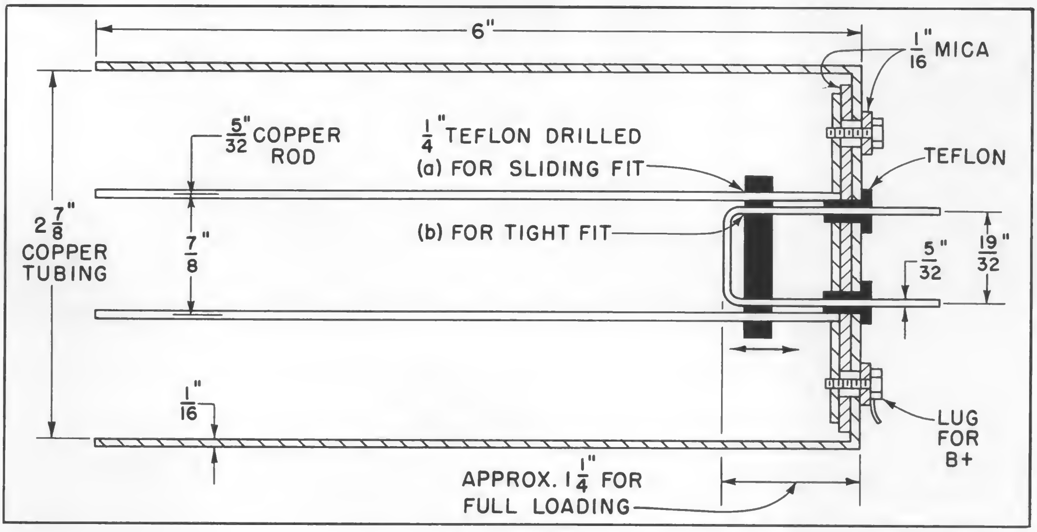


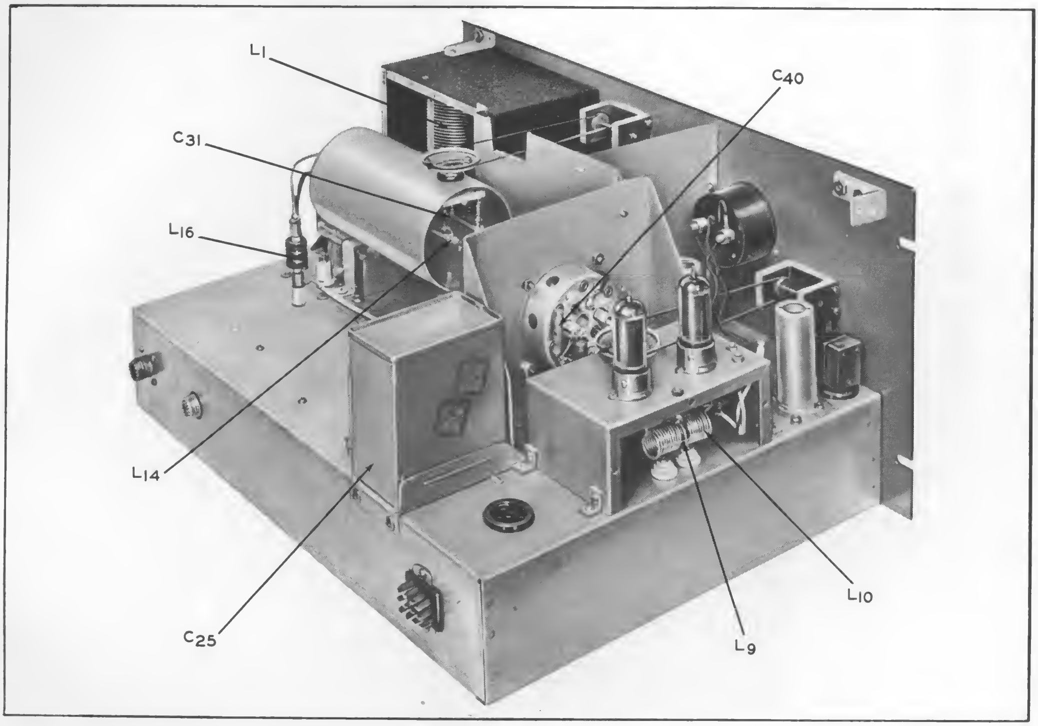
Figure 6. Construction details for the 144-Mc final tank assembly.

not have to be moved very often—even with relatively large frequency changes.

Be sure the plate tuning capacitor (mounted just inside the shield tubing) is insulated from ground, but that the shield itself is well grounded for rf by a 1″ copper ribbon at the plate end. These precautions, together with the system of screen bypassing used, will prevent a 200-Mc parasitic oscillation that may otherwise appear.

The antenna tuner is straightforward except that its capacitor rotor is also insulated from ground. Use ½″ stand-offs and an insulated shaft coupling. Keep this circuit well shielded. Because the rf fields at the tuner are strong, complete enclosure is essential to prevent possible TVI and feedback to earlier stages.

Figure 7. Detail view showing arrangement of components on the sub-chassis and the final socket.



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HAM TIPS
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144-Megacycle Transmitter

Part II: Operation and Adjustment

By R. M. Mendelson,* W2OKO

A description of this circuit and the schematic diagram and parts list appeared in Part I in the May issue of HAM TIPS. If you missed Part I, ask your RCA distributor for a copy.

Operation

After all wiring has been checked, insert RCA's 5763 crystal oscillator-tripler (V_3) and 5763 doubler (V_4). Use an 8-Mc crystal that will put the final signal near 146 Mc. If the coils are peaked for this frequency there will be adequate drive at both ends of the band. (A grid-dip meter to tune the coils roughly is a help. It is not essential, however.) Plug a 1- or 2-ma meter into J_1, apply 250 volts to the oscillator circuit and tune the plate of the oscillator (L_6) for a maximum reading. Approximately ½ to 1 ma should be obtained easily.

Now insert the push-pull tripler 5763's (V_5 and V_6) but do not connect them to B+. Move the meter to J_2 and add the doubler (V_4) to the B+ line. Tune doubler coil L_7 for maximum reading—between .75 and 2 ma. Spread or squeeze the tripler grid coils (L_{10}) for the highest maximum reading. If this reading is

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still too low, it may be necessary to couple link L_8 closer to the doubler coil. Moving this link will necessitate a touch-up of the doubler slug.

Insert the RCA-5894 final without B+ and let it warm up for 2 minutes. While waiting, set the screen bypass trimmer to the middle of its range. B+ should then be applied to all the multipliers but not to the final. Set excitation control R_{17} to maximum. Tune for maximum final grid-current by adjusting the plate-tank capacitor of the push-pull tripler. At least 5 ma should be indicated. Values of 8 ma have been obtained easily on the transmitter built. Back down R_{17} to give a reading of 4 to 5 ma.

Before applying high voltage to the final, it is wise to check for parasitics. Remove excitation by pulling out tripler tubes V_5 and V_6. Apply about 100 volts to the 5894 plate and screen circuit. Tune the final and push-pull tripler tuning capacitors through their ranges. If any combination of settings shows grid current, it indicates parasitic oscillation in the final stage. The usual procedure for hunting parasitics at VHF apply, but first make certain that the rotor of the final tuning capacitor is ungrounded. Adjustment of the screen bypass trimmer also may help. This trimmer setting is not critical, but in the absence of parasitics it should be set for maximum final grid current.

itance. Apply high voltage to the final, then immediately tune tank capacitor C_{31} for a dip in plate current. Adjust the antenna tuner for a maximum plate-current reading. The load bulb should light brightly.

With 450 volts on the plate, the current should be kept below 160 ma. If plate current is much less than this value, the loading may be increased by moving the antenna link a bit further in on the tank lines *(First, turn off the power.)* Little movement is necessary to obtain full load.

To check the antenna-coil tap spacing, replace the dummy load with the antenna coaxial feed-line and repeat the tuning procedure—starting with minimum coupling to the final tank. Begin with the antenna coil taps about ½ turn from each end. If peaking the antenna tuner changes plate tuning, move the taps about ⅛ turn. Repeat the tuning procedure until the correct tap points are found. You are now "on the air," crystal controlled.

VFO Adjustment

To start the VFO, remove power from final and multiplier stages and insert RCA's 6AU6 oscillator and 5763 buffer (V_2). Set the panel selector switch to "VFO" and apply B+ to the 6AU6. It should now be oscillating and its range may be checked on any communications receiver. For complete two-meter-band cover-

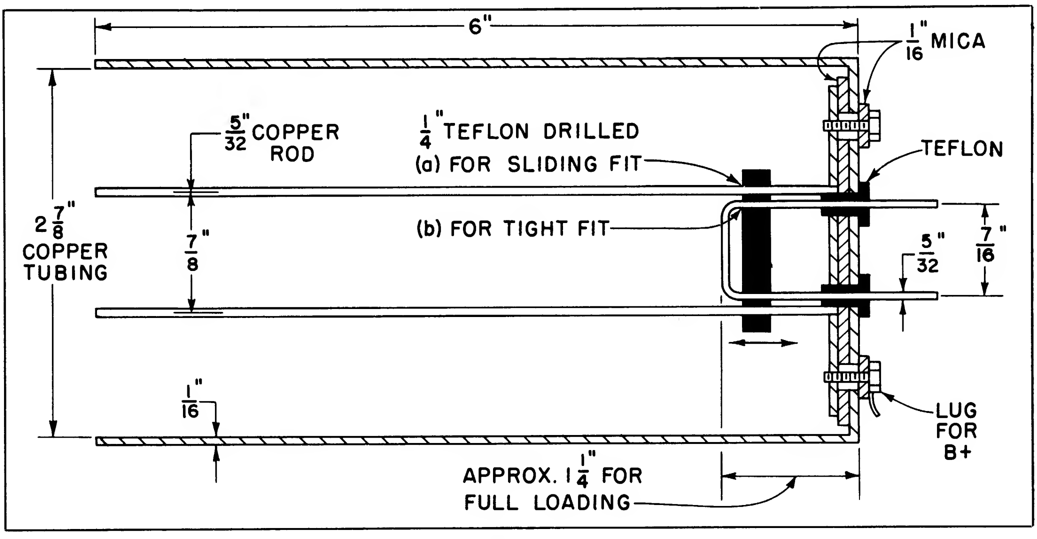

Figure 1. Transmitter tank assembly. Note corrected figure of 7/16" center-to-center for the antenna link.

The tripler tubes may now be reinserted and their plate circuit retuned for maximum final grid current. Next, a 100-watt lamp dummy load should be attached to the antenna tuner output. Pull the coupling link full out and set the antenna tuner for maximum capac-

age, the oscillator should tune from 8.00 to 8.22 Mc. Use C_1 to set the band edge. Calibration may be done either with the fundamental, on the low-frequency receiver or, later, on a two-meter receiver.

With the oscillator running, it is now only

necessary to tune the buffer plate to 8 Mc. Set the VFO to mid-band (8.11 Mc) and apply high voltage to all stages except the final. (The final may not have sufficient excitation until the buffer is adjusted.) Tune the buffer coil for maximum grid current at the final. The 5894 may now be fired up.

There will be a slight drop in final grid current when the VFO is tuned away from the center of the band, but adequate drive (4-5 ma) can always be obtained by proper setting of excitation control R_{17}.

Some thought was given to protecting the 5894 against loss of excitation. The use of a clamp tube on a modulated final is difficult at 144 Mc, where wires easily become quarter-wave lines. In the end, no protective devices were added here. No trouble has been encountered—so far.

Acknowledgment

The author wishes to thank James A. Shiels, K2DI, and Frank Maraguglio, W2LXB, for their ideas and aid in constructing the final tank and antenna tuner.

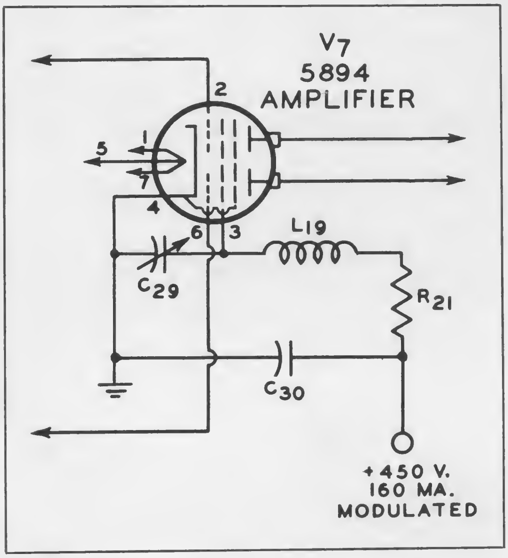

Figure 2. Original circuit used R_{21} without additional 5894 screen-lead choke, but addition of L_{19} (Ohmite Z-50) allows more complete neutralization of the final.

Addenda

In Part I, the center-to-center measurement for the antenna link (L_{15}) was incorrectly noted as 19/32". The correct dimension is 7/16".

Also in Part I it was noted that R_{21} served both as resistor and rf choke. It has been found, however, that the addition of an actual rf choke allows more complete neutralization of the final. (See Figures 2 and 3.)

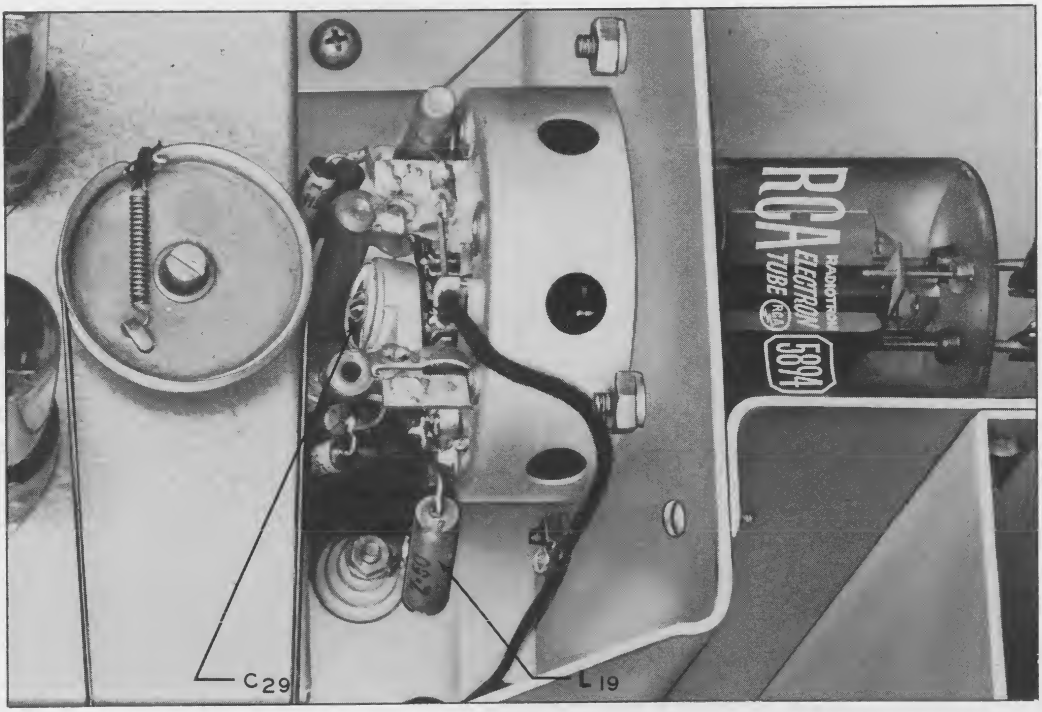

Figure 3. Close-up of the 5894 socket. L_{19} runs directly from screen pin to feed-through that connects with R_{21}.

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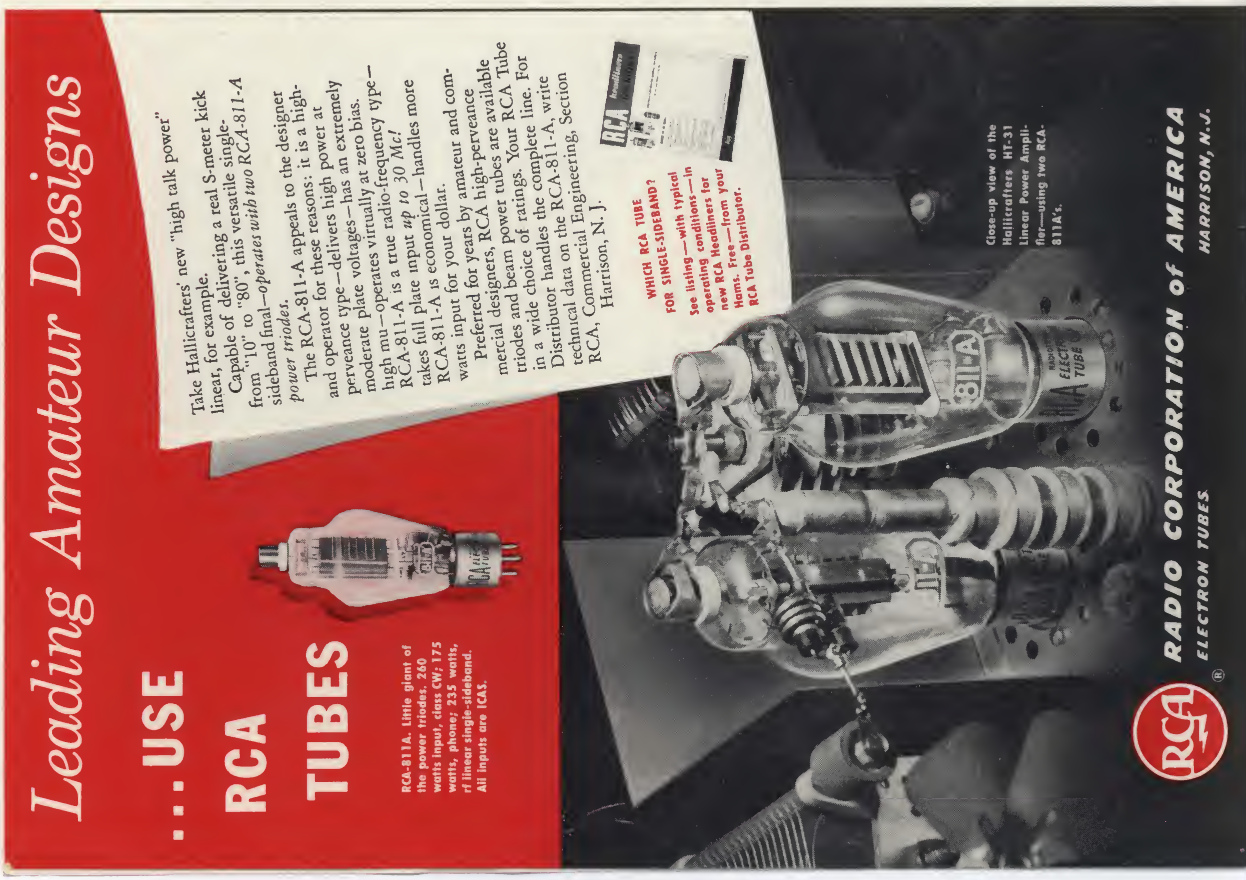

HAM TIPS

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Vol. XV, No. 3 October, 1955

Single-Ended Class-C Amplifier Design

By Clarence A. West, W2IYG

RCA Tube Division, Harrison, N. J.

The July-August, 1954 HAM TIPS gave a simplified procedure for the design of pi-coupled amplifiers. Now, W2IYG steps forward to discuss simplified design for single-ended Class-C amplifiers using balanced plate tank circuits.

Although much of the material presented here has been published piecemeal in one form or another, W2IYG has gathered the important considerations into this one article and boiled them down into simple, practical form.

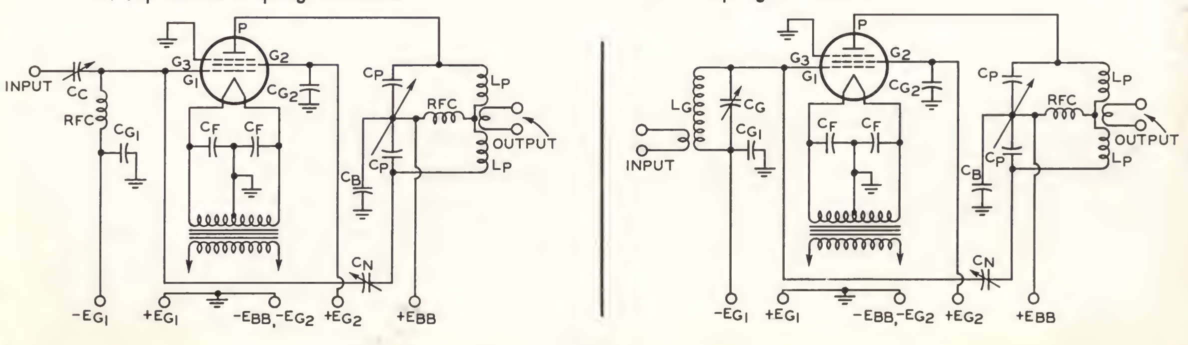
The basic circuit for single-ended Class-C amplifiers is essentially the same regardless of the tube type used; the chief problem confronting the designer is the selection of the proper component values for this circuit. The tuned circuits present the greatest difficulty, especially for those who plan to make their own coils and select capacitors suitable for use with these coils. The selection of other circuit components may also pose problems.

This article presents a "rule-of-thumb" approach to the selection of components for use in the circuits shown in Figures 1A and 1B. This approach, which eliminates the use of formulas and equations, provides workable circuits having adequate efficiency for most "ham" uses. A nomograph and a series of charts and curves enable the designer to determine quickly the value and rating of all circuit components including the physical constants of the coils. The step-by-step design procedure is as follows:

1. Select a suitable tube type.
2. Select a circuit, Figure 1A or 1B.
3. Select tube power output from tube data.
4. Determine peak plate voltage by multiplying dc plate voltage by 0.85.
5. On Nomograph, Figure 2, place straightedge on these values of power output and peak plate voltage. Read "Plate Load" value.
6. Place straightedge from this plate load value to the "Amateur Band" desired. Read

Figure 1. Basic Circuits. (When triodes are used, omit Grid-No. 2 and Grid-No. 3 circuitry.)

1A. Capacitance coupling from driver. **1B. Link coupling from driver.**



"Reactance X_C and X_L" value.

7. In Figures 3 and 4, *Reactance vs Capacitance and Inductance Curves,* read the values of tank capacitance and tank inductance required.

8. Determine minimum capacitor spacing, from Figure 8.

9. From Figure 5, *Coil Curves,* determine diameter, length, number of turns, and wire size required.

10. From Figure 6, *Miscellaneous Circuit Components Chart,* select values of other circuit components.

Before we run through a typical example, it is worth while to consider the important factors which influence tube selection.

Tube Selection

The selection of a tube to be used in the circuits covered by this article should not be made on the basis of tube power output alone. Equally important factors are: (1) tube output capacitance; (2) plate load; (3) driving power.

Tube output capacitance. This capacitance is added to the tank-circuit capacitance—thus changing the tank circuit's resonant frequency. At the lower frequencies this increase in tank capacitance is not serious, because the ratio of the tuning capacitance to the tube output capacitance is reasonably high. Thus, the tuning capacitor may be adjusted slightly to compensate for the tube output capacitance. At the higher frequencies, however, this capacitance ratio decreases and it may not be possible to reduce tuning capacitance sufficiently to obtain resonance within the band.

Plate load. A survey of popular power tubes used by amateurs reveals that most of them have plate load resistances in the range between 2500 and 5000 ohms. The Nomograph can be used for all popular types because it covers resistance values from 1000 to 5000 ohms. If the selected tube has a plate load resistance in excess of 5000 ohms, parallel operation of two or more lower-power tubes should be considered. The plate load resistance may also be reduced by operating the tube at a lower plate voltage and a higher plate current.

Driving power. The power output from the driver stage should be at least twice the grid driving power required by the driven tube. When sufficient driving power is available, the selection of a triode greatly simplifies circuit design because triodes in general have low output capacitances, are easy to neutralize, and have a plate load resistance of approximately 3500 ohms. In addition, grid-No. 2 and grid-No. 3 considerations are eliminated.

Typical Design Problem

The following sample design problem can easily be solved with the aid of the Nomograph, charts, and curves.

Problem: To design a 500-watt input class-C amplifier for CW telegraphy service, having a single-ended, balanced, plate tank circuit and a tuned grid-input circuit, for operation on 40 meters. Power output from an available driver stage is about 10 watts.

Procedure: Refer to a technical booklet such as the "RCA Headliners for Hams" (Form No. HAM 103B), which lists popular RCA types for amateur use. With the aid of such a publication, we find that a beam power tube or a pentode (for example, type 813) fits the driving-power requirements for the plate input involved.

Having selected an RCA-813 as the desired tube (step 1), we next choose our circuit (step 2). Because the driver stage is on a separate chassis, link coupling is desirable. Consequently, the circuit of Figure 1B is chosen.

3. The power input is 500 watts under the following typical ICAS conditions given in the tube data:

DC Plate Voltage	2250	volts
DC Grid-No. 3 Voltage	0	volts
DC Grid-No. 2 Voltage	400	volts
DC Grid-No. 1 Voltage	−155	volts
Peak RF Grid-No. 1 Voltage	275	volts
DC Plate Current	220	ma
DC Grid-No. 2 Current	40	ma
DC Grid-No. 1 Current (Approx.)	15	ma
Driving Power (Approx.)	4.0	watts
Power Output (Approx.)	375	watts

4. The peak plate voltage is 1910 volts (2250 x 0.85).

5. The plate load resistance, obtained from the Nomograph, is about 4900 ohms.

6. Also from the Nomograph, the reactances X_C and X_L required for a plate load of 4900 ohms at 40 meters are 800 ohms for each section of the plate tank, and 400 ohms for the grid tank.

7a. Figure 3 shows that: (1) The capacitance of *each section* (C_P) of the split-stator plate-tank capacitor is 27 $\mu\mu$f at the mid-frequency. A capacitor of 50 $\mu\mu$f (each section) should be used to provide adequate band coverage. (2) The inductance of *each section* of the plate-tank inductor is 17 μh.

7b. Figure 4 shows that: (1) The capacitance of the grid-tank capacitor is 55 $\mu\mu$f

at the mid-frequency. A capacitor of 100 $\mu\mu$f should be used to provide band coverage. (2) The inductance of the grid-tank inductor is 8.9 μh.

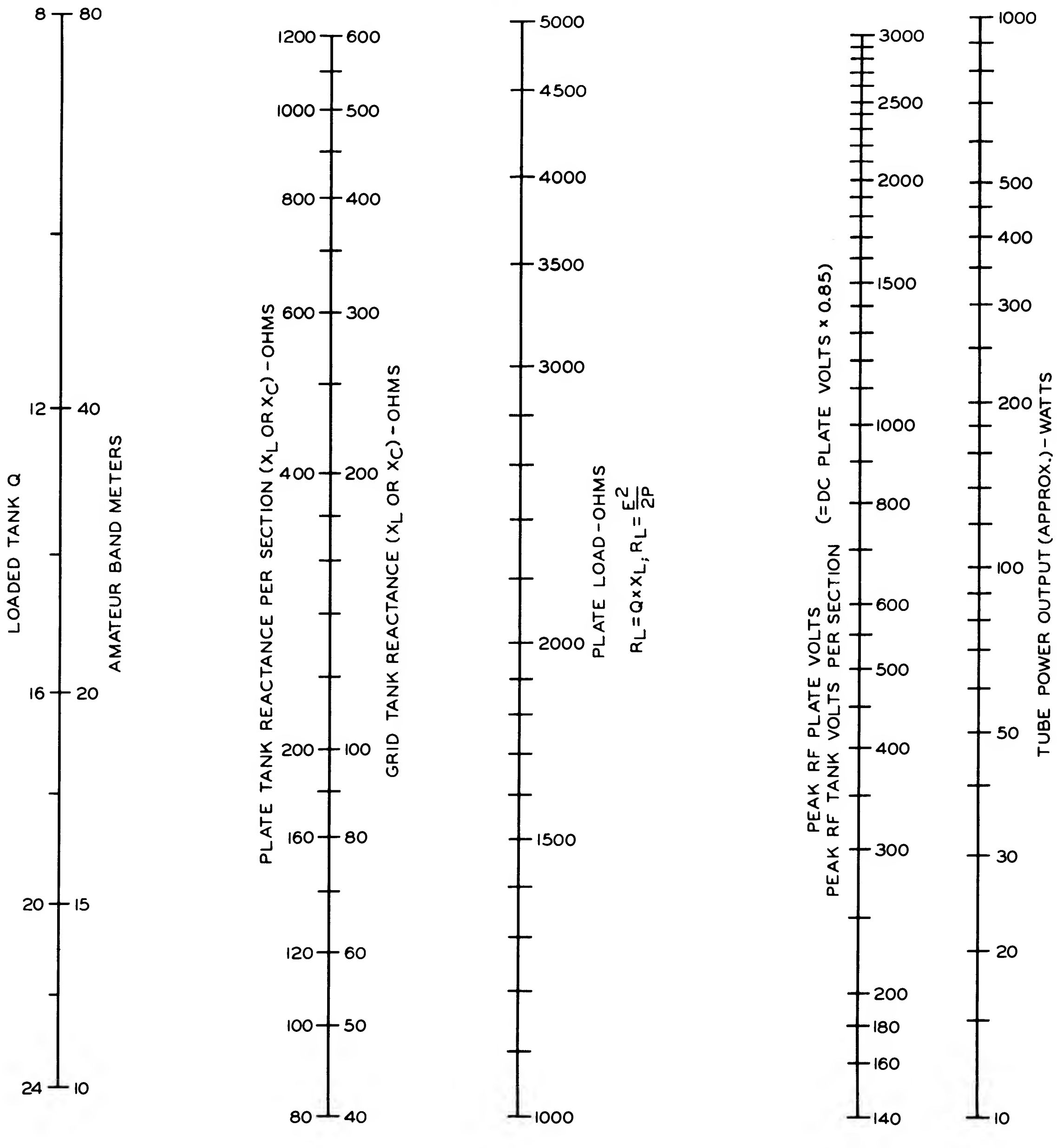
8 a. Figure 8 shows that rotor-to-stator spacing for each section (C_P) of plate-tank capacitor for a peak rf plate voltage of 1910 v = 0.06″, minimum. (For telephony service, the peak rf plate voltage is 2 x 1910 v = 3820 v, and the spacing would be increased to 2 x 0.06″ = 0.12″, minimum.)

8 b. Figure 8 also shows that rotor-to-stator spacing of grid-tank capacitor (C_G) for a peak rf grid voltage of 275 v = 0.01″, minimum distance (approximately).

9a. Step 7a showed that the plate tank inductance required is 17μh for each section, or a total inductance of 34 μh. Referring to Figure 5, we find curves for 1-inch, 2-inch, and 3-inch diameter coils. The table of wire-sizes shows that No. 10 wire is suitable for a tank coil used in conjunction with a tube having a 375-watt power output.

The Wire Table in Figure 5 shows that the maximum number of turns per inch for No. 10 wire is 9 turns. Referring next to the curves in Figure 5 (for three representative coil-form dimensions), we find that an inductance of

Figure 2. Nomograph.



34 μh requires 56 turns on a form having a 1″ diameter and a 2″ length, 41 turns on a form of 2″ diameter and 4″ length, and 32 turns on a form 3″ in diameter and 6″ in length. However, we have already noted that no more than 9 turns per inch can be wound with No. 10 wire, so it is clear that the coil form of 3″ diameter and 6″ length is the only one of the three which allows the necessary number of turns of No. 10 wire for an inductance of 34 μh. (For the experimenter willing to design coils using coil forms other than those used for the curves in Figure 5, the equation shown with the curves will be of value.)

9b. Step 7b showed that the grid-tank inductance required is 8.9 μh. Referring to Figure 5 again, with a tank inductance of 8.9 μh, and with #18 wire (suitable for power levels below 75 watts), we find that 30 turns on a 1-inch coil diameter and a 2-inch winding length provide the inductance required.

10. From the circuit shown in Figure 1B and from the "Miscellaneous Circuit Components Chart," Figure 6, we find that the following additional components, with indicated ratings, are required:

CAPACITORS

Capacitance	Working Voltage Volts (Minimum)	Type
Bypass:		
Filament, C_F		
0.001 to 0.01 μf	200	Disc Ceramic
Grid-No. 1, C_{G1}		
0.001 μf	200	Disc Ceramic
Grid-No. 2, C_{G2}		
0.001 to 0.005 μf	400	Disc Ceramic
Plate, C_B		
0.001 μf	2250	Mica
Neutralizing, C_N:		
0.5 $\mu\mu$f max.	4500	Variable-Air

RF CHOKES

Inductance mh	Current Rating Ma (Minimum)	Type
Plate:		
2.5	220	Any
Grid No. 1:		
2.5	15	Any

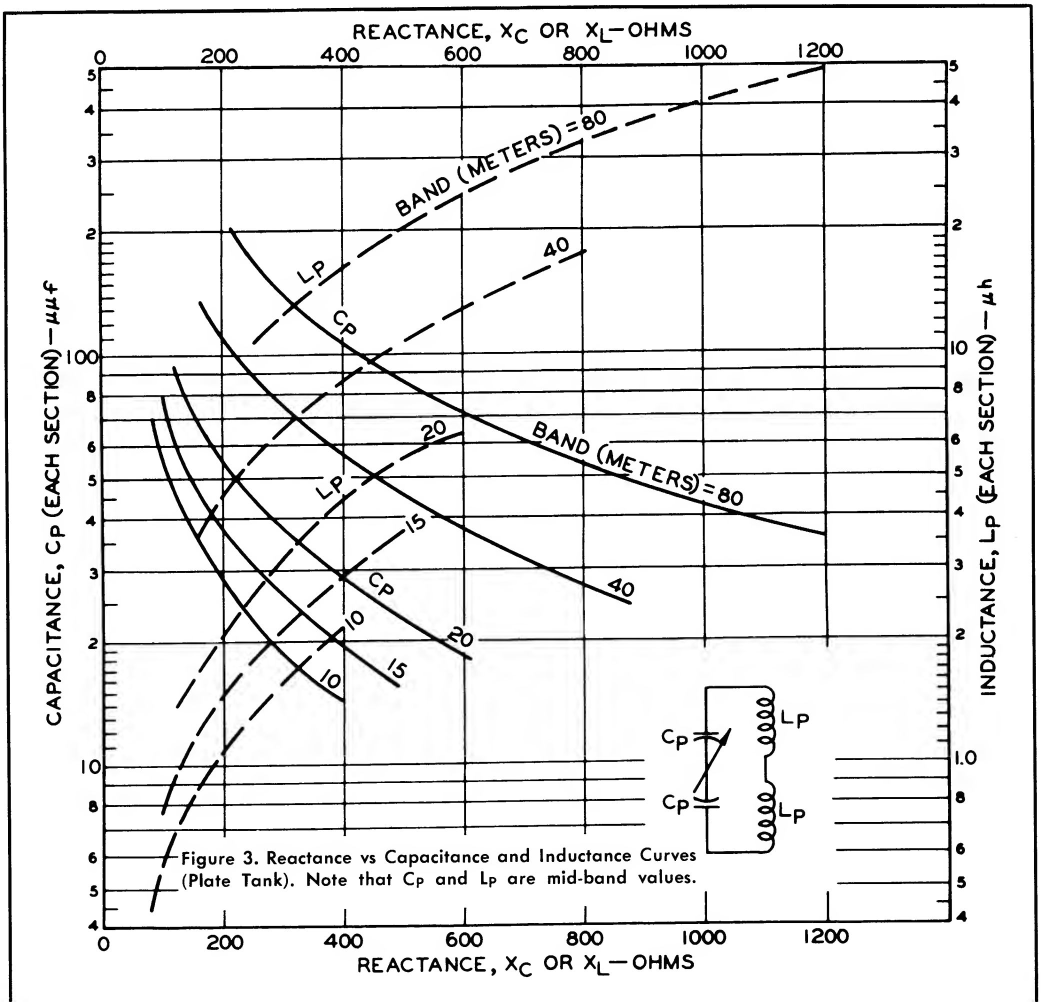


Figure 3. Reactance vs Capacitance and Inductance Curves (Plate Tank). Note that C_P and L_P are mid-band values.

That's all there is to it. You've designed a complete final stage, to the required specifications. If you're in a rush to get "on the air," you can stop reading right now and plug in your soldering iron. The balance of this article is a discussion of the various charts and tables, with some thoughts on plate tank circuits in general.

Basic Circuits

The circuits discussed in this article were selected for the following reasons:

1. They are very popular.
2. They are easily adjusted and require no special balancing. Neutralization is simple and straightforward.
3. All components can be easily obtained, and are available in great variety at relatively low cost.
4. There is less likelihood of TVI from single-ended balanced tank circuits than there is from the average push-pull amplifier.
5. A balanced tank circuit with link coupling allows easy installation of a low-pass filter designed to work on 50- or 75-ohm lines.

The Nomograph

The Nomograph (Figure 2) provides a simple method for solving a set of equations with reasonable accuracy. It indicates the proper plate load for any tube operating at a power level between 10 and 1000 watts and at dc plate voltage between 165 and 3500 volts. The Nomograph also relates "plate load" and "operating frequency" to the proper value of capacitive and inductive reactance required in the tank circuit. (It is important that the reactances X_C and X_L, along with loaded Q, be the specified values, to ensure proper plate loading and good circuit efficiency.) The Nomograph, used in conjunction with the single-ended balanced tank circuits shown in Figures 1A and 1B, also aids in the selection of a tube suitable for use with these circuits, as discussed under "Tube Selection."

To permit the use of practical values of tank C and L over the amateur bands from 80 through 10 meters, the Nomograph has been designed so that suggested values of loaded tank Q vary with the amateur band being used (Q increases with frequency).

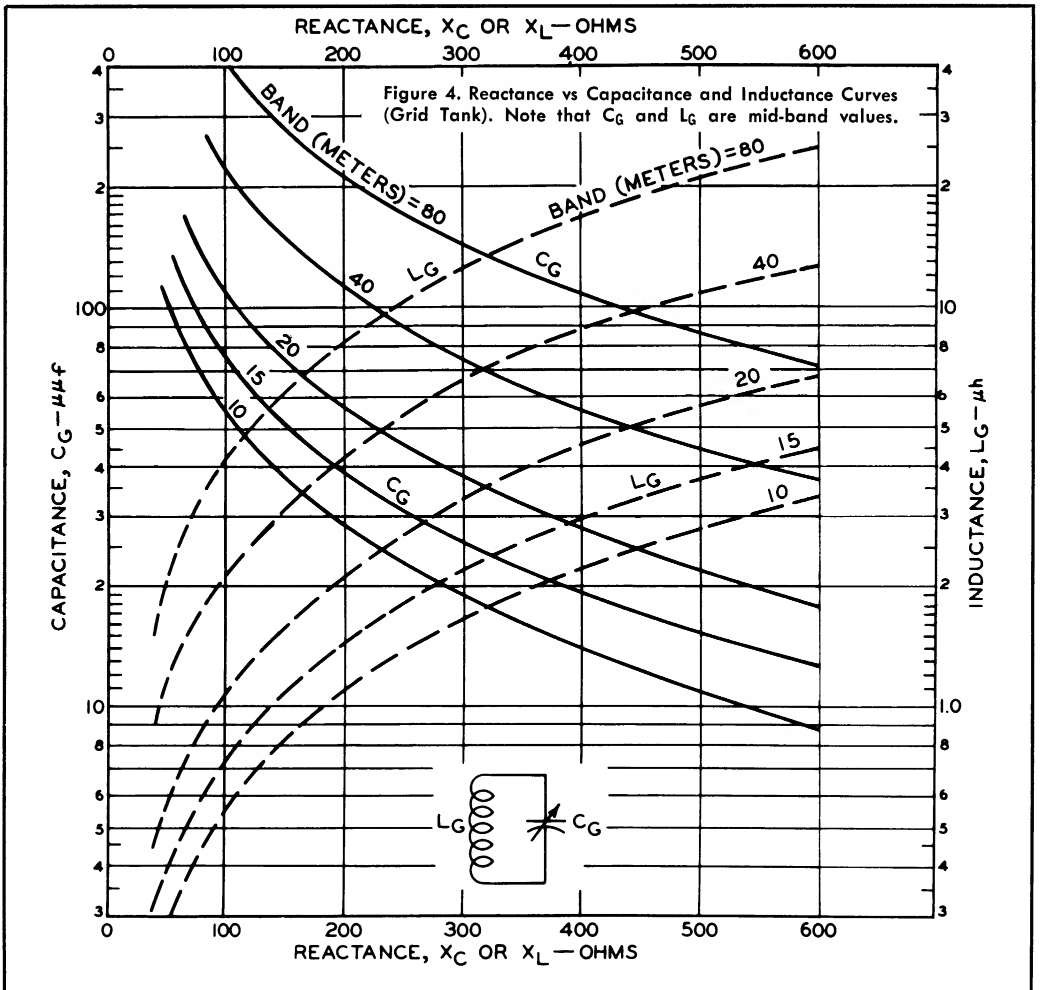


Figure 4. Reactance vs Capacitance and Inductance Curves (Grid Tank). Note that C_G and L_G are mid-band values.

Plate Tank Circuit Considerations

As mentioned in "Tube Selection," the minimum value of the tuning capacitor is an important consideration for operation at the higher frequencies. It is good engineering practice to select a capacitor having the lowest possible minimum capacitance because, whenever circuit constants are such that the tube output capacitance becomes a major consideration, a capacitor of low minimum value will allow more flexibility in the choice of the amplifier tube.

Regarding tuning-capacitor range, calculations show that, for tuning the amateur bands, the maximum percentage change in capacitance from the value at mid-frequency is approximately ±15%. As a safety factor, a tuning capacitor having a minimum tuning range of ±30% should be adequate. Before testing a new amplifier, it is advisable to use a grid-dip oscillator to check the tuning range of each tank circuit with tubes in their sockets but no voltage applied.

Neutralization

Most class-C amplifiers must be neutralized in order to prevent self-oscillation. Triodes always require neutralization when used in the circuits shown in this article, whereas beam power tubes or pentode tube types may

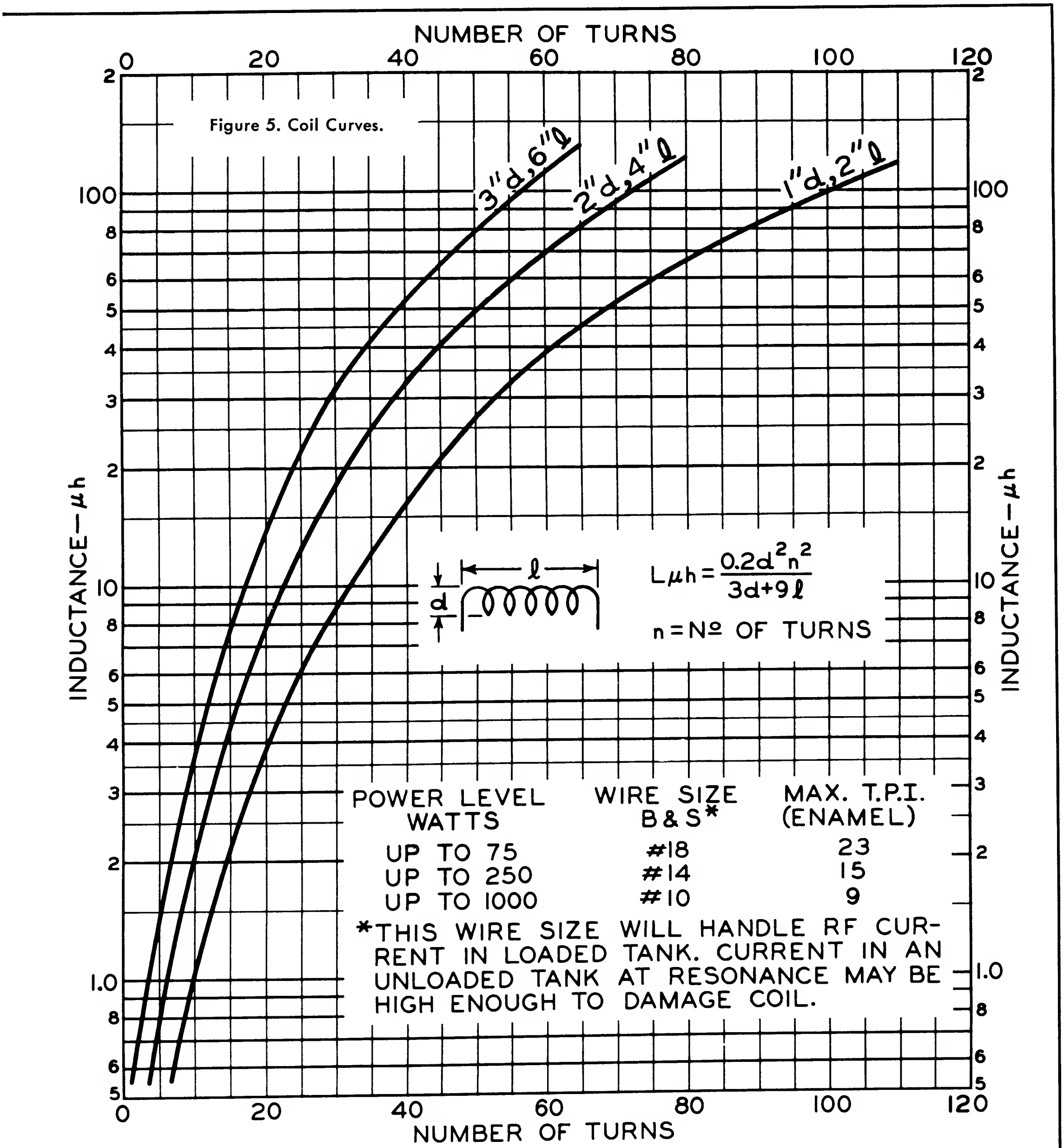


Figure 5. Coil Curves.

require neutralization or may not.

When input and output circuits of beam power tubes or pentode tube types are effectively isolated and good bypassing is employed, it is generally not necessary to provide for neutralization. However, it is difficult to build such an amplifier and, therefore, many amateurs are confronted with the problem of a self-oscillating amplifier when a new final is tested. Because the inclusion of a small neutralizing capacitor during the building of a new amplifier is a comparatively simple task, the capacitor is a worthwhile addition in view of its contribution to stable operation.

Neutralizing capacitors required for beam power tubes and pentode tube types are usually on the order of 1/4 $\mu\mu$f. If it should prove difficult to obtain a neutralizing capacitor of this low value, it is a simple matter to construct your own. The capacitor shown in Figure 7 is variable from about 1 $\mu\mu$f to 0.06 $\mu\mu$f, and will be adequate for most beam power tubes or pentodes. For those wishing to design their own neutralizing capacitor, the equation $A = 4.5\ Cd$ is suitable, where A is the area of one plate in square inches; C is in $\mu\mu$f (approximately twice the grid-No. 1-to-plate capacitance is an appropriate value); and d is the distance between plates in inches (see Figure 8 for minimum spacing).

Figure 6. Miscellaneous circuit-components chart.

CAPACITORS

Value	Minimum DC Working Voltage — Volts: Telegraphy	AM Telephony	Type
COUPLING, C_C 0.0001 μf	E_{bb} of driver $+E_{g1}$ of driven stage	E_{bb} of driver $+E_{g1}$ of driven stage	Variable, air; or fixed mica
BYPASS:			
Filament, C_F 0.001—0.01 μf	200	200	Disc ceramic
Grid No. 1, C_{G1} 0.001 μf	E_{g1}	E_{g1}	Disc ceramic
Grid No. 2, C_{G2} 0.001—0.005 μf	E_{g2}	2 x E_{g2}	Disc ceramic
Plate, C_B 0.001 μf	E_{bb}	2 x E_{bb}	Disc ceramic
NEUTRALIZING, C_N 2 x Grid No. 1—plate capacitance (Max.)	2 x E_{bb}	4 x E_{bb}	Variable, air

RF CHOKES

Value	Current-carrying Capacity	Type
GRID 2.5 mh (Approx.)	At least I_{g1}	Any
PLATE 2.5 mh (Approx.)	At least I_p	Any

Figure 7. Small neutralizing capacitor.

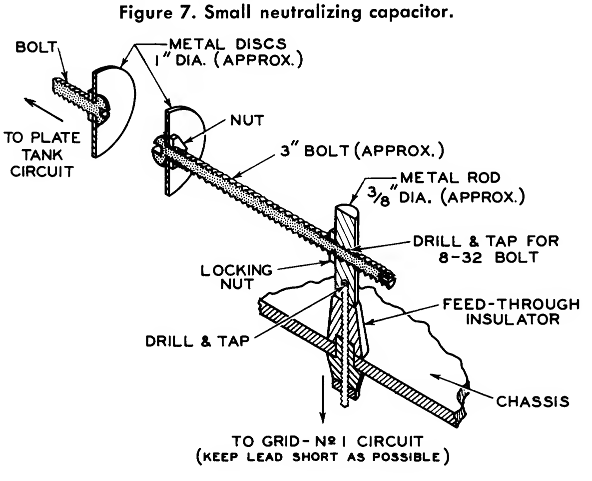
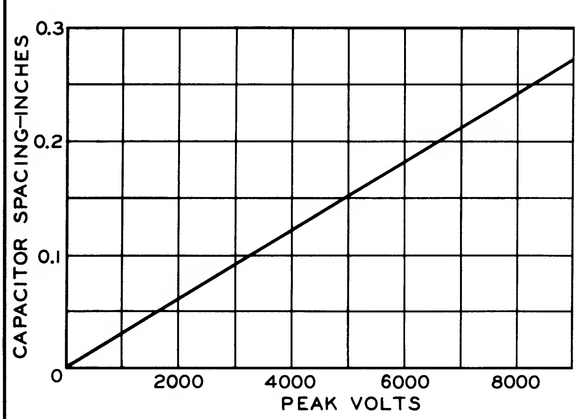


Figure 8. Capacitor-spacing Graph.



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Technical Editor

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A SECONDARY FREQUENCY STANDARD

By R. M. Mendelson, W2OKO
RCA Tube Division, Harrison, N. J.

W2OKO set out to design a frequency standard for ham use that would equal or surpass the performance of many commercial units. After reading his article most hams will be inclined to agree he has succeeded admirably. Here is a secondary frequency standard that can be built by the average ham with little difficulty and, more important, at low cost. It provides accurate and highly stable 10-Kc, 100-Kc, and 1-Mc markers, with the 1-Mc markers readable up to 250 Mc. In addition to marking the ends of amateur bands, it may be used for receiver calibration, for frequency measurement of received signals, for supplying an accurate, stable signal when "polishing" crystals, and as a signal generator for intermediate-frequency or front-end alignment.

"The licensee of an amateur station shall provide for measurement of the emitted carrier frequency . . . of sufficient accuracy to assure operation within the frequency band used." (FCC Regulation 12.135)

A versatile frequency standard providing 1-Mc harmonics readable to at least 250 Mc, 100-Kc harmonics readable to 150 Mc, and 10-Kc harmonics readable to 30 Mc is described in this article. The fifth harmonic of the 1-Mc oscillator may be set to within less than ½ cycle of the 5-Mc signal of WWV—the radio station of the National Bureau of Standards. This is an accuracy of better than one part in 10 million. And, if the instrument is allowed to warm up, its setting after 24 hours of operation in a room of fairly constant temperature will still be within 5 cycles of the 5-Mc signal of WWV—a drift of no more than one part per million. These figures may be more clearly appreciated when it is realized that the dials of the most expensive amateur communications receivers have divisions no smaller than 1 Kc, and are readable at best to 500 cycles.

The complete schematic diagram of the unit is shown in Figure 1. A cathode-coupled crystal oscillator circuit utilizing an RCA-12AT7 (V_1) operates at a fundamental frequency of 1 Mc. One triode section of V_1 operates as a cathode follower, the other triode section as a grounded-grid amplifier. The crystal and capacitor C_4 act as a series-

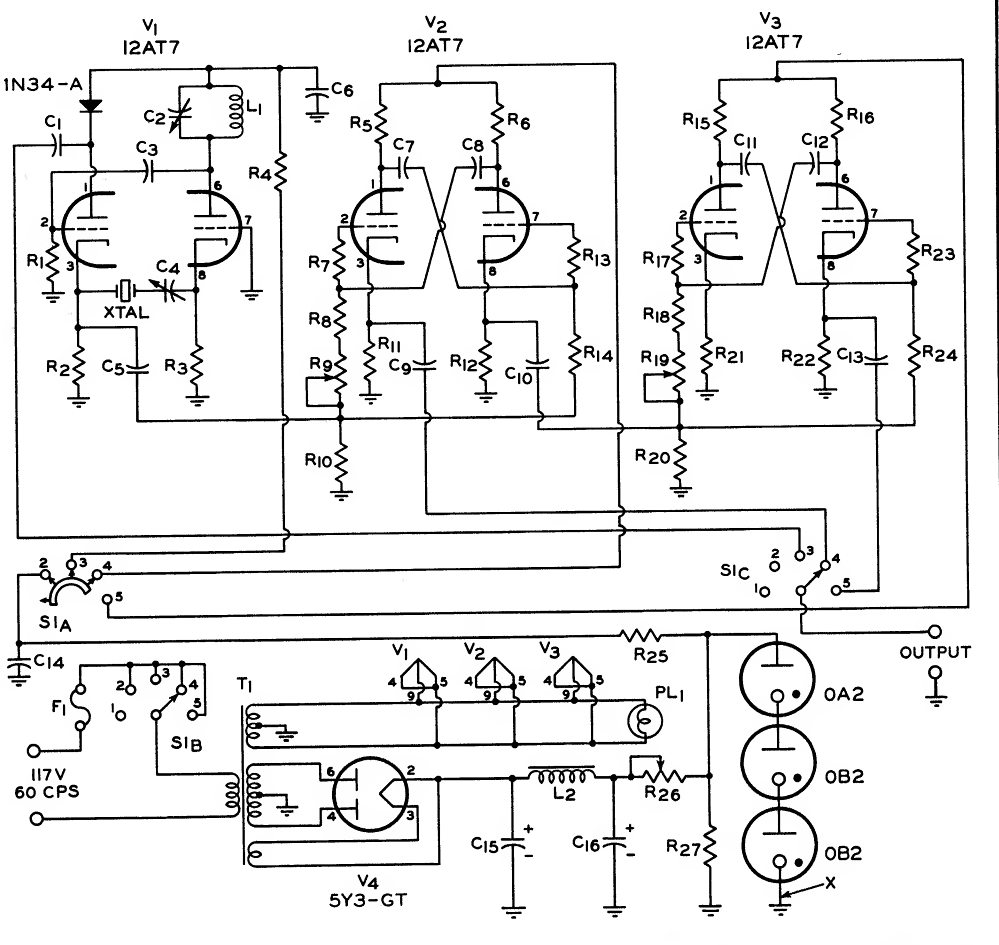


Figure 1. Schematic diagram and parts list. Positions of the three-pole ganged switch S1 are as follows: 1—Off; 2—Standby; 3—1 Mc; 4—100 Kc; 5—10Kc (S1 shown in 100-Kc position). S1 switches three circuits, but only two switch sections are needed because S1A and S1B are on opposite faces of same section.

C_1	15 $\mu\mu$f silver mica (Sangamo RR-1415).
$C_{2,4}$	50 $\mu\mu$f variable, with lock (Hammarlund APC-50C).
C_3	500 $\mu\mu$f silver mica (Sangamo RR-1350).
C_5	2000 $\mu\mu$f silver mica (Sangamo CR-1220).
C_6	2500 $\mu\mu$f mica (Elmenco CM-30).
$C_{7,8}$	270 $\mu\mu$f silver mica (Sangamo RR-1327).
C_9	100 $\mu\mu$f silver mica (Sangamo RR-1310).
$C_{10,13}$	1000 $\mu\mu$f silver mica (Sangamo RR-1210).
$C_{11,12}$	1500 $\mu\mu$f silver mica (Elmenco CM-30).
C_{14}	.01 μf ceramic (Erie GP-333).
$C_{15,16}$	40 μf, electrolytic, 500 WVDC (Mallory FP-288).
F_1	Fuse, 3 AG, 2 amp.
L_1	Plate tank inductance (Grayburne Varichoke V6). See text for modification.
L_2	Filter choke, 8 h, 85 ma (Stancor C1709).
PL_1	Pilot light, 6-8v (#40 or #47).
R_1	100,000 ohms ± 5%, 1 watt.
$R_{2,3,10,11}$, $R_{12,20,21,22}$	1,000 ohms ± 5%, 1 watt.
R_4	3,000 ohms ± 5%, 1 watt.
$R_{5,6}$	10,000 ohms ± 5%, 1 watt.
$R_{7,13}$	200 ohms ± 5%, 1 watt.
$R_{8,18}$	5,500 ohms ± 1%, 1 watt (Continental Carbon X1).
$R_{9,19}$	Potentiometers, 5,000 ohms (Clarostat 58-5000).
$R_{14,24}$	7,450 ohms ± 1%, 1 watt (Continental Carbon).
$R_{15,16}$	39,000 ohms ± 5%, 1 watt.
$R_{17,23}$	51 ohms ± 5%, 1 watt.
R_{25}	1,000 ohms ± 5%, wire-wound, 10 watts.
R_{26}	3,000 ohms wire-wound adjustable, 10 watts (Ohmite 1029).
R_{27}	82,000 ohms ± 5%, 1 watt.
S_1	3-pole, 5-position ceramic rotary switch (Centralab sections GG, R, and index assembly P121). See text for modification.
T_1	Power transformer, 320-0-320 v, 70 ma; 5 v, 2 amp; 6.3 v, 2.5 amp. (Stancor PC8408).
XTAL	Crystal, 1 Mc ± .0025%, hermetically sealed (International Crystal Manufacturing Co. FX-1).

Miscellaneous

Chassis	7" x 9" x 2", steel (Parmetal C-4511).
Cabinet with Panel	12¾" x 8" x 8½", steel (Parmetal CA-300).
Turret Sockets	9-pin (Vector type 6N9T). Three needed.
Crystal Socket	Ceramic (Millen 33302).
Binding Posts	(Superior 5-way). Two needed.

resonant circuit between the two cathodes. Because the crystal operates in a low-impedance circuit, it is affected only slightly by variations in tube or stray capacitance across it.

The fundamental frequency of the crystal oscillator circuit may be varied several hundred cycles by adjustment of C_4. This flexibility eliminates the need for a specially calibrated crystal and allows any well-designed hermetically sealed crystal to be used.

L_1 and C_2 form a circuit that is parallel-resonant at 1 Mc and serves as the plate-load impedance for the grounded-grid amplifier. C_3 provides feedback to the grid of the cathode follower. The RCA-IN34-A diode provides high harmonic content in the cathode-follower output.

V_2 and V_3, also RCA-12AT7's, are cathode-coupled multivibrators operating at 100 Kc and 10 Kc, respectively. V_2 is controlled by the injected 1-Mc signal from the crystal, and is synchronized at the proper sub-harmonic by adjustment of R_9. V_3 is controlled by the injected 100-Kc signal from V_2 and is synchronized at the proper sub-harmonic by adjustment of R_{19}.

The stability of this frequency standard is enhanced by voltage regulation of the power supply and by careful layout that keeps heat away from the crystal.

Construction

Although the oscillator is, in itself, very stable, its best performance can be obtained only with sturdy construction. Toward this end, turret sockets are used for the three frequency-generating stages. The terminal lugs on the turrets hold the small parts rigidly and minimize the effects of vibration or shock. To minimize rf losses, bus wire leads are used extensively. And finally, only "quality" parts are used. The advantage of a resistor or capacitor that will hold its value with age more than offsets the few cents extra in cost.

The placement of components has been carefully designed to keep heat sources away from the crystal and the one-megacycle tuned circuit, and it is suggested that the builder follow the layout illustrated in Figures 2 and 4.

Instead of the usual practice of fastening the chassis to the lower portion of the panel, this chassis is bolted to the panel about halfway up. This arrangement allows freer circulation of air within the cabinet, and at the same time yields a neater panel appearance. Two screws through the back of the cabinet support the chassis from the rear.

To provide a small, sturdy coil (L_1) for the 1-Mc tuned circuit, it was deemed best to use a commercial slug-tuned coil. However, the coil specified in the parts list had slightly too much inductance to resonate at 1 Mc in the circuit as built at W2OKO. Rather than pull turns off the heavily waxed coil, a small brass slug 11/16" long by ¼" in diameter (cut from an old potentiometer shaft) was used in place of the original iron slug in the coil form. The iron slug was removed and the brass one cemented into the open end of the coil form, flush with the end of the form. This brass slug lowered the inductance of L_1 sufficiently to allow it to resonate at 1 Mc with C_3 and the associated stray capacitance. [*The 1-Mc coil LS-3 manufactured by Cambridge Thermionic Corp. should resonate without modification in this circuit. Ed.*]

The other item to be modified is the ceramic switch. If the switch is assembled from the components specified in the parts list, it is

VALUABLE DATA FOR HAMS

A revised and enlarged edition of the *RCA Receiving Tube Manual*—for many years the amateur's guide to electron tubes and circuits—is now available from your RCA tube distributor.

Like former editions, the latest Manual contains a well-rounded section on electron-tube theory, tube characteristics and applications. Another section contains 22 schematic diagrams illustrating tube applications. And this new 336-page edition features a 26-page supplement filled with data on 51 tube types recently added to the RCA line.

All-in-all, the revised *RCA Receiving Tube Manual* (RC-17) belongs close to hand in every ham shack.

While you're at it, ask your RCA tube distributor to show you the newest edition of RCA's popular *Power and Gas Tubes Booklet* (Form PG-101B). This completely revised 24-page booklet contains the latest technical data on 178 vacuum power tubes; gas, mercury-vapor, and vacuum rectifier tubes; gas and mercury-vapor thyratrons; ignitrons; magnetrons; and vacuum-gauge tubes. Each tube type is covered by a text description, tabular data, and a base- or envelope-connection diagram—all easy to locate and highly informative. In addition, photographs are shown of many representative tube types. No matter what your interest is in power or gas tubes and their applications, the new RCA *Power and Gas Tubes Booklet* is sure to be of value.

only necessary to hacksaw carefully through the shorting ring of the GG section, drill out one rivet and remove part of the ring, as shown in Figure 3. This modification provides single-knob control for application of high voltage to the proper tubes as the various output frequencies are selected.

Adjustment

After the wiring has been carefully checked, adjust R_{26} to about 2000 ohms, and insert a 50-ma meter in series with the string of voltage regulator tubes (at point X in Figure 1). Apply ac power by rotating the control knob to "Standby." After warm-up, note the current flowing through the regulator tubes. A value of 30 ma is desired. *Shut off the power* and adjust R_{26} accordingly. It will later be noted that as V_1, V_2, and finally V_3 are put into operation by the control switch, the regulator current will drop, due to current drain by these tubes. If 30 ma of regulator current flows during standby, there should still be a slight current flowing in the 10-Kc position, when all tubes are operating.

Loosely couple the frequency standard to a communications receiver. With capacitors C_2 and C_4 at mid-position, turn the control switch to the "1 Mc" position and locate a low harmonic signal at, for example, 2, 3, or 4 Mc. With the receiver beat-frequency oscillator turned off, adjust C_2 for a maximum reading on the receiver's S-meter. It should now be possible to detect clean, strong, signals at 1-Mc intervals up to well over 250 Mc.

To adjust the 100-kc multivibrator, set potentiometer R_9 to mid-position and tune the receiver to a band where continuous coverage of at least 1 Mc is available. It is now best to operate with the receiver bfo turned on. Locate and note two points on the dial 1 Mc apart by tuning in signals from the standard. Rotate the control switch to the 100-Kc range, and tune in one of the multivibrator harmonics between the 1-Mc markers. If R_9 happens to be set properly, the note should be clean; if the note is rough, adjust R_9 to give a steady, controlled signal. Then, starting at one of the previously noted 1-Mc marks, tune the receiver through the range to the other marker. Numbering the first 1-Mc marker as "1", there should be 11 markers up to and including the last 1-Mc marker note. If there are less, increase R_9; if more, decrease R_9 to obtain control at the correct sub-harmonic of 1 Mc. Repeat the process until the proper number of markers are counted. These should be clean signals, with no rough notes between. In this condition, signals should be heard in a good receiver to well over 150 Mc.

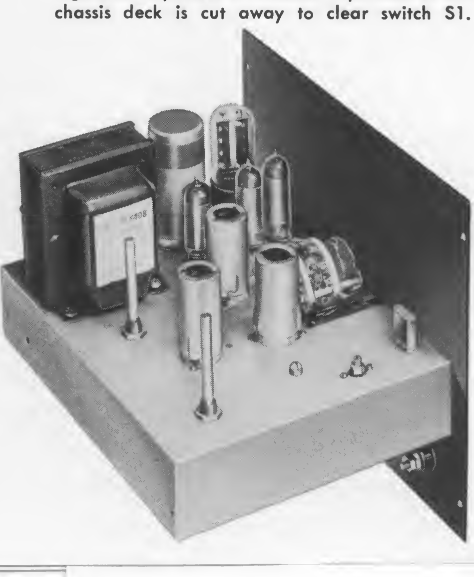
To adjust the 10-Kc multivibrator, set potentiometer R_{19} to mid-position and tune the receiver to a band where a continuous coverage of at least 100 Kc is available. As above, locate two end points—this time 100 Kc apart—and then rotate the control switch to the "10 Kc" position. Proceed as before. Tune in a signal between the 100-Kc markers, adjust R_{19} for a smooth note, then count the notes between the end markers. Adjust R_{19} for a count of 11 clean beats (including the end markers).

At this point, check that the voltage regulator tubes are still glowing. Although the glow should be faint, the current reading on the meter should be about 8 to 10 ma. If it is not, readjust R_{26}, *after shutting off the power*. The meter may now be removed from the circuit.

Before proceeding with the final adjustment of the crystal oscillator it is well to age the components for about 48 hours with the switch set for 10-Kc signals. After aging, check the multivibrators for proper synchronization. After this check, the frequency standard is ready for calibration against WWV.

The standard may be calibrated by matching the proper harmonic of its 1-Mc signal against either the 5-Mc or 10-Mc signal of WWV. It should be noted that there are a number of methods of frequency-matching more accurate than the system of eliminating an audible beat note. The method used at W2OKO was similar to that described on p. 462 of the 1955 ARRL *Radio Amateur's Handbook*. By this method (using the receiver bfo), the standard was set with ease to within less than ½ cycle of WWV's 5-Mc signal, as noted earlier in this article.

Figure 2. Top view of chassis. A portion of the chassis deck is cut away to clear switch S1.



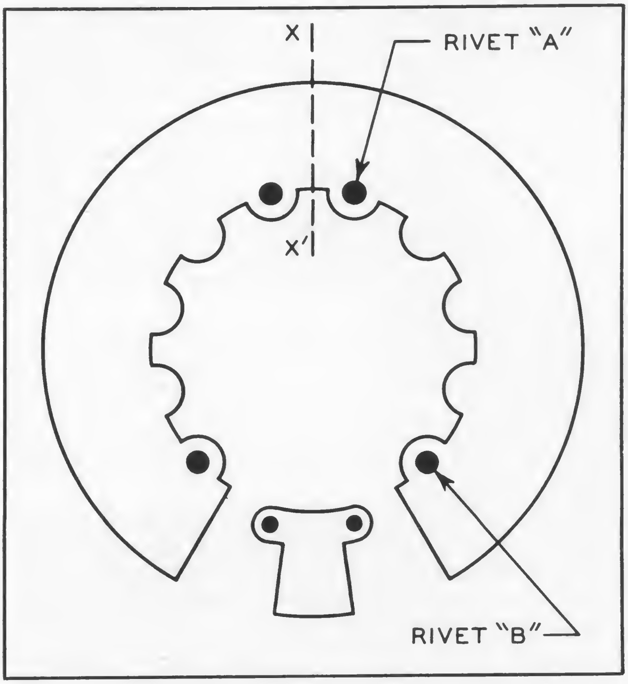
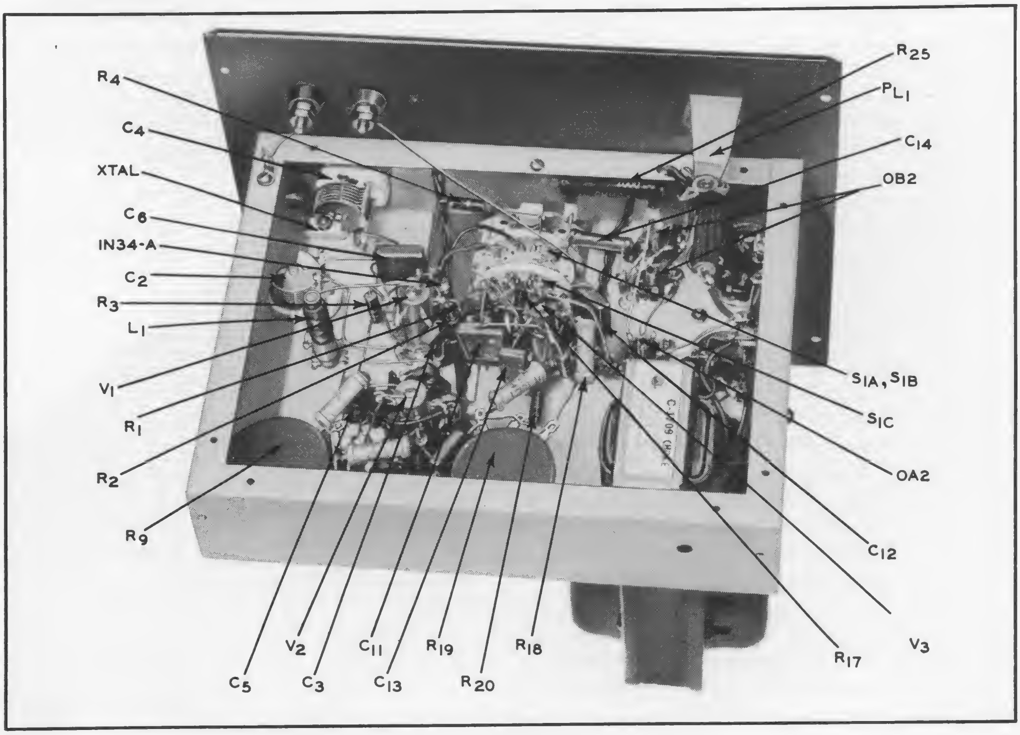


Figure 3. $S1_A$ face of switch section GG before modification. ($S1_B$ is on opposite face of this section.) Saw through switch plate along line X-X'. Drill rivet "A" until it is loose, but do not remove. Drill rivet "B" and remove. Remove portion of switch plate to right of line X-X'. Crimp rivet "A" tight again. (Rivet "A" helps secure $S1_B$.)

Figure 4. Bottom view of chassis. Note brass slug mounted inside the coil form of L_1. The placement of components has been designed to keep heat sources away from the crystal and the 1-Mc tuned circuit (L_1, C_2); turret sockets allow neat, sturdy construction. It is suggested that the builder follow this layout as closely as possible.



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73

...and happy hunting for '56

HAM TIPS

RCA

A PUBLICATION OF THE RCA TUBE DIVISION

Vol. XVI, No. 1 March, 1956

HAM-BAND CHARTS

Useful Data on Ham Bands from 1.8 to 148 Mc

One of the most popular items ever to appear in *RCA Ham Tips* was the amateur-band frequency graph printed in the September-October, 1949 issue. In response to many requests from hams, we are devoting this issue to printing an up-to-date revision of that graph, plus other data thrown in for good measure.

Figure 1 is a graph showing the harmonic relation between the six amateur bands from 10 to 160 meters. It is designed to replace the slide-rule-and-aspirin method of solving a number of common amateur problems.
Some examples:

(a) You have a 7,080-Kc crystal you want to use—in conjunction with multiplier stages —for operation on the 20-meter band. Instead of reaching for pencil and paper, glance at Figure 1. Run your eye down the line marked 7.08 Mc until you reach the 20-meter bars. You find that everything is OK if you plan to work CW or TT. If you're a 'phone man, you'd better reach for another crystal.

Conversely, Figure 1 may be used to determine quickly the ranges to be covered by intermediate stages as you multiply to higher frequencies.

(b) You decide that most of your time will be spent working 'phone on the 20-meter band. Your present VFO covers the range of 3,500 to 4,000 Kc. Figure 1 shows you that (after multiplying frequency) only 1/20 of your VFO dial will be useful to you. A modification of the VFO bandspread system might be in order. Thus Figure 1 is also useful for determining the *relative* sizes of these six bands as you multiply frequency.

Figure 2, on the other hand, shows the *absolute* sizes of the ham bands from 10 to 80 meters. (The 160-meter band is not shown here because it is sub-divided on a geographical basis.) For example, this graph makes it clear that there is 12 times as much room on the 'phone portion of the 10-meter band as there is on the 'phone portion of the 20-meter band.

Because the 2-, 6-, and 11-meter bands are not easily related to the lower bands, they are treated separately. Figure 3 is a chart that shows useful sub-harmonics of the band limits of these three bands. For example, Figure 3 shows that a VFO covering the range of 8.000 Mc to 8.222 Mc would—after the frequency had been multiplied 18 times—spread the 2-meter band across the entire dial. Or, if you have a 6,770-Kc crystal, Figure 3 indicates that after quadrupling you would be within the limits of the 11-meter band.

Note that frequencies in Figure 3 have been rounded off (where necessary) on the "high side" at the lower band-edge limits, and on the "low side" at the upper band-edge limits.

All data shown in Figures 1, 2, and 3 represent the latest *FCC* rulings. Don't take it out on *Ham Tips* if you hear other services operating in "ham bands." Regulations in other parts of the world may allow broadcast, aeronautical or other services to use portions of these bands. Similarly, some foreign hams may be permitted to use ham bands slightly larger than ours. They may be "in the clear" —but *you* won't be if you try to zero-beat them.

Figure 1. Graph of amateur bands from 10 to 160 meters, showing sub-band allocations and the harmonic relation between bands.

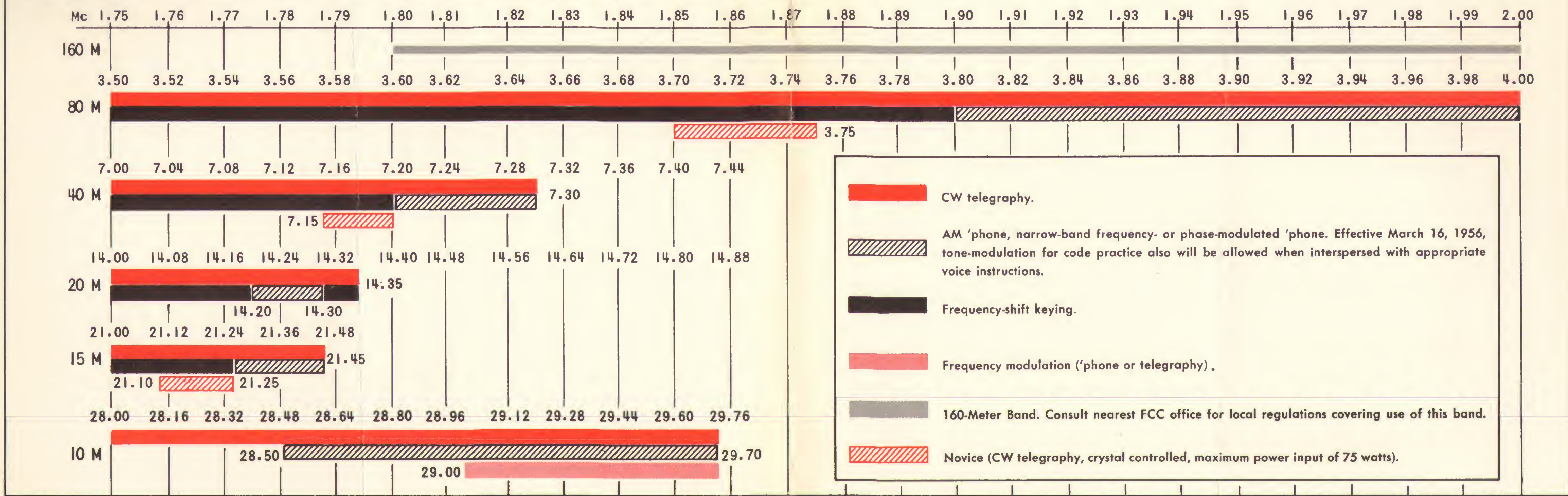

Figure 2. Graph of amateur bands from 10 to 80 meters, showing extent of each band in kilocycles. Key for sub-band allocations same as in Figure 1.

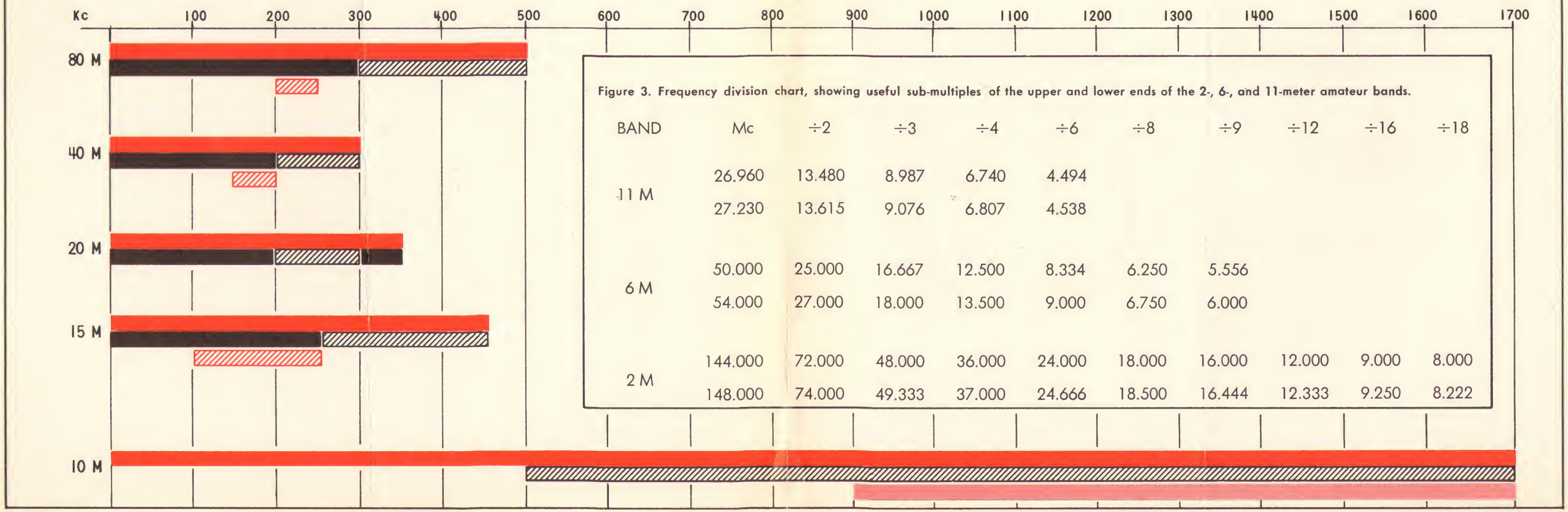

Figure 3. Frequency division chart, showing useful sub-multiples of the upper and lower ends of the 2-, 6-, and 11-meter amateur bands.

BAND	Mc	÷2	÷3	÷4	÷6	÷8	÷9	÷12	÷16	÷18
11 M	26.960	13.480	8.987	6.740	4.494					
	27.230	13.615	9.076	6.807	4.538					
6 M	50.000	25.000	16.667	12.500	8.334	6.250	5.556			
	54.000	27.000	18.000	13.500	9.000	6.750	6.000			
2 M	144.000	72.000	48.000	36.000	24.000	18.000	16.000	12.000	9.000	8.000
	148.000	74.000	49.333	37.000	24.666	18.500	16.444	12.333	9.250	8.222

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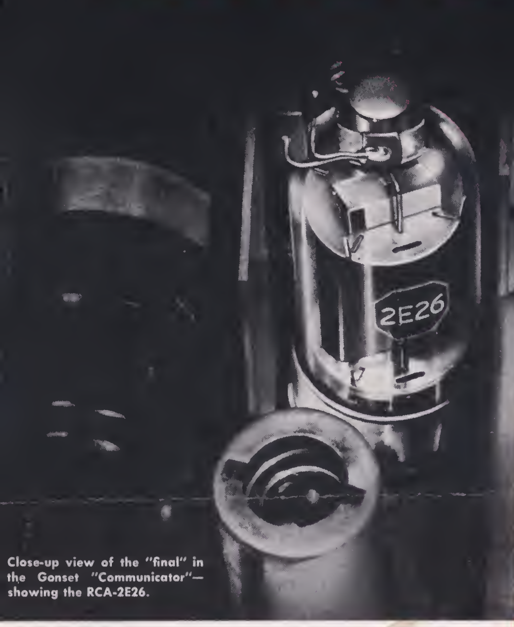

Close-up view of the "final" in the Gonset "Communicator"—showing the RCA-2E26.

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RCA-2E26 Beam Power Tube. Up to 40 watts ICAS input on cw: 27 watts phone. Full input up to 125 Mc; reduced input up to 175 Mc. Well-suited for mobile services. A 6AG7 drives it; a pair of 6V6-GT's, or a 6N7, modulates it.

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HAM TIPS

A PUBLICATION OF THE RCA TUBE DIVISION

Vol. XVI, No. 2 July-August, 1956

VERSATILE MODULATOR

by Peter Koustas, W2SGR

RCA Tube Division, Harrison, N. J.

The modulator described in this article can furnish any audio power between 25 and 100 watts and, therefore, can modulate 100% any rf input power up to 200 watts. Maximum power output is determined primarily by the plate voltage applied to the modulator tubes. No circuit changes are necessary when the power output level is changed other than in the connections to the proper taps on the modulation transformer.

The input circuit, which will accommodate any type of microphone, utilizes a transistor because of its low power consumption. The stability and low noise factor of the RCA-2N104 made it a logical choice for this application.

Circuit Description

A schematic diagram of the modulator is shown in Figure 1.

The transistor circuit given here is straightforward and not at all critical. The RCA-2N104 is a germanium alloy-junction transistor of the p-n-p type intended especially for small-signal audio applications. It is shown connected here in a common-emitter, base-input circuit. This method of transistor operation is analagous to common-cathode operation of a vacuum tube triode — with the base, emitter, and collector of the transistor corresponding to the grid, cathode, and plate, respectively, of the vacuum tube.

However, unlike the vacuum tube, which has a high input impedance at audio frequencies, the input impedance of the 2N104 in the circuit shown is approximately 1,000 ohms. Thus, low-impedance microphones (e.g.: carbon or dynamic types) may be used in this circuit without matching transformers. Crystal microphones, and other high-impedance types, do require a matching transformer in this circuit and one has been provided (T_1).

The RCA-12AT7 is a twin triode with two identical sections, each having a μ of 60. One section is used to provide a second stage of voltage gain; the other serves as the driver stage for the modulator tubes. In order to take advantage of the full gain afforded by the transistor, an impedance-matching, 3-to-1 step-up transformer is used between it and the input to the second stage. Modulation level is controlled by a 250,000-ohm potentiometer in the grid circuit of the first section of the 12AT7. Resistance coupling is used between the second and third stages of the modulator. Decoupling between stages is provided by R_{16} and C_9. Driver requirements are very modest, since no power is required to drive the modulator to full output. The second section of the 12AT7 develops adequate drive with no difficulty.

The outstanding features which make the RCA-6146 such a proven performer in rf service are the very reasons this versatile tube was chosen for the output stage of this modulator: high perveance and high power sensitivity. The high perveance of the 6146 allows this modulator to operate efficiently at low power levels with relatively low plate voltage. The high power sensitivity of the 6146 en-

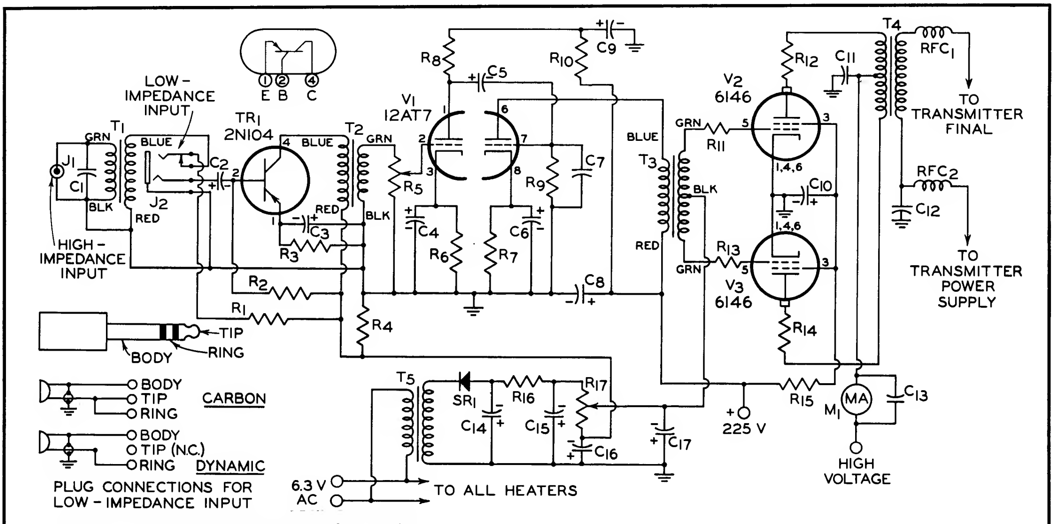

Figure 1. Schematic diagram and parts list.

C_1	500 $\mu\mu$f; mica	$R_{12,14}$	47 ohms, 1 watt
C_2	16 μf, 12 v; miniature	R_{15}	1,000 ohms, 1 watt
C_3	25 μf, 12 v; miniature	R_{16}	2,200 ohms, 2 watts
$C_{4,6}$	25 μf, 25 v	R_{17}	10,000 ohms, 25 watts; adjustable
C_5	.01 μf, 400 v	$RFC_{1,2}$	2.5 mh, 125 ma
C_7	.002 μf, 400 v	SR_1	Selenium rectifier, 65 ma (RCA-205G1, or equivalent)
$C_{8,9,10}$	8 μf, 450 v	T_1	Transistor input transformer, 200,000 ohms primary to 1,000 ohms secondary impedance (Argonne AR-100, or equivalent)
C_{11}	0.5 μf, 750 v		
C_{12}	.005 μf, 1500 v; mica		
C_{13}	0.1 μf, 600 v		
$C_{14,15,16}$	20 μf, 150 v	T_2	Interstage transformer, single plate to single grid, 1:3 turns ratio (Stancor A-53, or equivalent)
C_{17}	8 μf, 150 v		
J_1	Jack (Amphenol 80F, or equivalent)		
J_2	Jack, (Mallory 703B, or equivalent)	T_3	Interstage transformer, single plate to push-pull grids; 10,000 ohms primary impedance, 1.5/1:1 primary-to-½ secondary ratio (Stancor A-4752, or equivalent)
M_1	Meter, 0-100 ma		
R_1	3,300 ohms, ½ watt		
R_2	220,000 ohms, ½ watt		
$R_{3,11,13}$	1,000 ohms, ½ watt	T_4	Universal modulation transformer, 100-115 watts (UTC S-21, or equivalent)
R_4	470 ohms, ½ watt		
R_5	Potentiometer, 250,000 ohms	T_5	Filament transformer, 6.3 v, 1 amp (Stancor P-6134, or equivalent)
R_6	2,200 ohms, ½ watt		
R_7	390 ohms, 1 watt	TR_1	Transistor, RCA-2N104
$R_{8,9}$	270,000 ohms, ½ watt	V_1	RCA-12AT7
R_{10}	22,000 ohms, 1 watt	$V_{2,3}$	RCA-6146

ables this modulator to deliver full power output with negligible power required from the driver stage.

The 6146's are operated class AB_1 for all power levels up to a maximum of 100 watts. A driver transformer (T_4) which has a tapped primary is used to provide push-pull signal voltage for the output tubes. If sufficient gain is not available for a particular microphone when using the 1.5-to-1 tap, an additional tap on the primary can provide a primary-to-½ secondary ratio of one-to-one. Two 1,000-ohm resistors in series with the grid leads of the 6146's are used for the suppression of parasitic oscillations. The 47-ohm resistors in each plate lead serve the same purpose. Although these resistors are seldom necessary in audio equipment, it is always good practice to include them as a precautionary measure.

The modulation transformer that was selected can handle the maximum power output of the modulator. (The difference in price between a 60-watt transformer and this 115-watt transformer is less than five dollars). To determine the correct *secondary* impedance it is only necessary to divide the input voltage to the transmitter final by the normal operating current. The correct *primary* impedance will range from 2,500 to 7,500 ohms, depending upon operating voltage. Figure 2(b) is a plot of the *minimum* primary impedance required to prevent tube damage, versus operating plate voltage.

Figure 2(a) is a plot of output power versus plate voltage applied to the 6146's. To determine the required modulator plate voltage for a particular transmitter, divide the input power to the final stage of the transmitter by

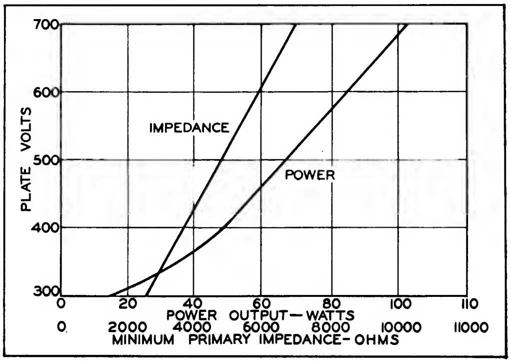

Figure 2. a) Power output vs plate voltage
b) Minimum primary impedance vs plate voltage

two, to get the audio power required for 100% modulation. Now find the minimum plate voltage required from Figure 2(a).

Higher plate voltages than those found from the above procedure may be used, and the modulation adjusted to the correct level by potentiometer R_5. In any event, R_5 should be used for fine adjustment of modulation level.

A few words of caution should be injected at this point. *Never* operate any modulator without having a load connected to the output. The high impedance of an unloaded transformer secondary reflected into the primary will cause abnormally high signal voltages to be generated and will almost always cause the insulation of the transformer to be punctured. Also, to prevent damage to the 6146's, never operate this modulator with the primary impedance of the output transformer below the value given in Figure 2(b) for the plate voltage being used.

Construction

Construction of the modulator is not difficult and requires only normal care in wiring. It is built on a standard aluminum chassis 5x13x3 inches deep and mounted on a rack panel 5¼x19 inches. This method of construction has two distinct advantages: a) a minimum of panel space is required; b) more complete shielding is obtained by utilizing the panel as the bottom cover of the chassis.

It is necessary to scrape the paint off the panel where the chassis comes in contact with it in order to insure a good rf bond between them.

The leads to the input jacks and gain control must be about five inches long, in order to allow assembly of the panel to the chassis after it is wired. It is therefore necessary to shield these leads to minimize any tendency towards stray hum and feed-back pickup. For maximum effectiveness, all parasitic-suppressing resistors must be mounted right at the tube socket, and directly on the plate cap.

Power Supplies

Two external voltage supplies are required by the modulator.

The first supply is for the plates of the 6146's. The voltage rating of this supply will depend on the modulation power output desired, as determined from Figure 2(a). Zero-signal drain on this supply will be between 50 and 60 ma. At 750 v, maximum-signal drain will be approximately 230 ma. The power supply should be capable of supplying maximum-signal current with good regulation.

The second external power supply must deliver approximately 50 ma at 225 volts. This supply powers the 12AT7 and the screen grids of the 6146's. It should never be turned on until after the plate supply has been turned on. Preferably, the supplies should be so wired that the plate supply must be on before the low-voltage supply can be energized.

Operating voltage for the transistor and bias for the modulator tubes are supplied by an internal supply. *This supply should be turned on before either of the above supplies.* Again, sequential switching to ensure the proper order of energizing the supplies is to be preferred. Transformer T_5 is a 6.3-volt filament transformer connected in reverse to obtain 115 volts from the 6.3-volt heater supply. A selenium rectifier and RC filter (R_{16}, C_{14}, and C_{15}), provide a negative voltage supply of −100 volts. Resistors R_1 and R_2 form a voltage divider between ground and the junction of R_{17} and R_4, which provides the 5 volts required to operate the transistor. Bias for the 6146's is adjusted by moving the tap of R_{17} to the appropriate point.

Operation

Other than usual precautions, there is no special procedure required to place the modulator in operation. The wiring should be thoroughly checked before any power is applied. With the tubes but not the transistor inserted, apply 6.3 v to the heater-voltage input terminals. The bias voltage at the grids of the 6146's should be set initially at maximum and then adjusted when all other voltages in the modulator are applied so that the zero-signal plate current as read on the meter is approximately 55 ma. Before insertion of the transistor, the voltage between ground and the junction of R_{17} and R_4 should be measured. If it is between 4.5 and 6 v, plug in

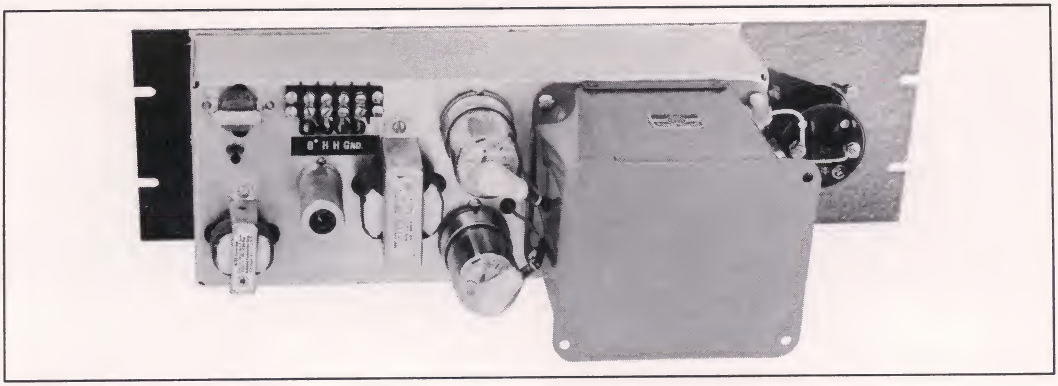

Figure 3. Rear view of modulator

the transistor. If the voltage at this point exceeds 6 v, a wiring mistake or a wrong value for R_4 may be the cause.

The modulator may be tested separately by using a resistor of the correct value as a load. The resistor used should have the same resistance as the impedance of the secondary taps to which it is connected and should be of sufficient power rating to withstand the output of the modulator. Power output may be measured by applying an input signal and measuring the signal output voltage across the resistor. The output power will be $\frac{(E_{rms})^2}{R}$. Again, a warning: in no case should the modulator be run without having a load connected to the secondary of the modulation transformer.

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HAM TIPS

A PUBLICATION OF THE RCA TUBE DIVISION

Vol. XVI, No. 3 September, 1956

THE MAKE-YOUR-OWN MICROPHONE

High Quality, High Output with a Transistorized Microphone

By G. D. Hanchett, W2YM

RCA Tube Division, Harrison, N. J.

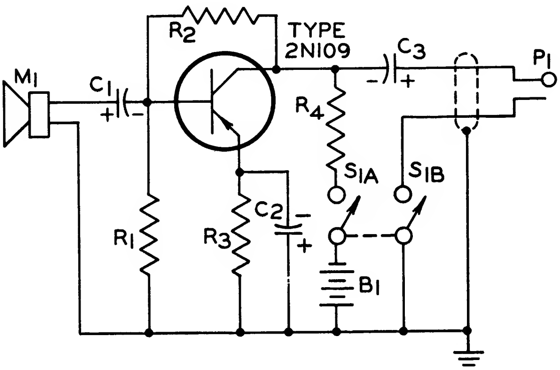
During the design of a mobile rig the author was recently confronted with the problem of finding a suitable microphone. A carbon microphone, although high in output, is noisy and of relatively uneven frequency response. A crystal microphone has good frequency response but is low in output and has the additional disadvantage — for mobile use especially — of temperature limitations.

An attempt was made, therefore, to construct a microphone that would have good audio quality, be fairly high in signal output, be rugged enough for mobile ham use, be insensitive to unwanted electrical pickup, and still be within the price range of the average ham. This article describes the result; a surprisingly simple build-it-yourself microphone that meets all the given requirements.

Because of the abovementioned limitations of carbon and crystal microphones, they were discarded in favor of a dynamic "mike." The motor chosen for the microphone is the new RCA 239S1 2⅛" miniature PM speaker. The motor works into a one-stage, transistorized amplifier. Both motor and amplifier are contained in a small metal box that fits the hand comfortably.

The output of the microphone's built-in amplifier ranges between 0.75 v and 1.0 v measured across a load of 20,000 ohms or more. The audio quality of this microphone surpassed all expectations; in fact, for voice use it compared favorably with a so-called broadcast-quality crystal microphone. The total cost of the home-made "mike" (exclusive of the metal case, which was formed from sheet aluminum) was less than $10.00!

Figure 1 is a schematic diagram of the microphone. An RCA-2N109 p-n-p junction transistor is connected in a common-emitter, base-input amplifier circuit. Degeneration, provided through R_2, stabilizes the transistor against the effects of temperature variations. Push-button switch S_1 serves two functions: one pole (S_{1A}) energizes the transistor amplifier; the other pole (S_{1B}) can be used to control the transmitter.



B_1	Transistor battery, 9 v (RCA VS300, or equivalent).
$C_{1,2}$	50 μf, 12.5 v.
C_3	2.5 μf, 25 v.
M_1	Microphone, RCA 239S1 2⅛" miniature PM speaker.
P_1	Male plug, 2-contact (Amphenol 80-MC2M, or equivalent).
R_1	10,000 ohms, ½-watt.
R_2	68,000 ohms, ½-watt.
R_3	1,200 ohms, ½-watt.
R_4	8,200 ohms, ½-watt.
S_1	Switch, push-button, double-pole single-throw, non-locking.
	RCA-2N109 Transistor.

Figure 1: Schematic diagram and parts list.

Construction

The microphone is assembled in an aluminum box 3" L by 2¼" W by 1½" H. At W2YM the box was made by folding a sheet of aluminum cut to the proper pattern, welding the corners, and applying a coat of paint to the outside. If no welding equipment is available, the aluminum may be bent to form lips that may be bolted together. The box may also be formed from brass or copper, in which case the edges can be soldered together.

A 2-inch hole is cut in the front of the box to accommodate the 239S1 speaker. A piece of Reynolds "Do-It-Yourself" perforated aluminum is placed over the hole, inside the box, to serve as a protective screen for the speaker.

The transistor, its socket, and the associated small components for the amplifier were mounted on a strip of linenized bakelite. Any good insulating material, however, can be used for the mounting board. Even cardboard should be suitable.

The leads of the components are passed through #60 holes drilled through the mounting board. Where the leads come through the holes at the back of the mounting board they are bent into small hooks with a pair of long-nosed pliers. These hooks in the leads hold the components to the mounting board and also make for easy connection to the leads. Caution: be sure to observe polarity when connecting the capacitors.

The mounting board is held in place inside the box by two of the screws that fasten the speaker. These two screws should be long enough so that the mounting board can be held above the speaker by two ⅝"-long, ¼"-wide spacers.

If the transistor battery is placed in the position shown in Figure 3 before the mounting board is fastened into place, it should be found that the mounting board—when finally fastened down — will serve to hold the battery in place. It might be wise, however, to stick a small piece of insulating tape on the inside of the box near where the negative terminal of the battery will be located. This precaution will remove any chance of the battery accidentally shorting to the box.

The bass response of the microphone can be adjusted by damping the miniature speaker. To obtain suitable damping, cover nine holes in the rear housing of the 239S1 with felt. The felt may be held in place with ordinary household cement. The tenth and last hole in the rear of the housing should be covered with a piece of fiber or cardboard that has a 1/32" hole drilled through for pressure release. Another pressure-release hole, this one ⅛" in diameter, is drilled in the back cover plate of the microphone case. With this construction, the frequency response of the microphone is smooth through the range of 400 to 4,000 cps. Response, particularly at the low end, falls off rapidly beyond these limits — a desirable feature for a communications microphone.

Actual construction time for this microphone should be no more than a few hours. The author believes that the finished product is the best microphone for amateur communications now available. Try it and you'll agree.

The author wishes to thank J. Owens, W. Davies, F. Boryszewski, F. Wenzel, and J. Preston for their valuable aid or suggestions during the construction and testing of this microphone.

Figure 2: All components of the microphone and transistor amplifier. Note felt strips and fiber strip with small hole that are placed over the rear-housing holes of the speaker. Brackets to right of center are made from angle brass stock and are used to mount back cover on the case. One bracket has been cut away to clear grommet at bottom of case.

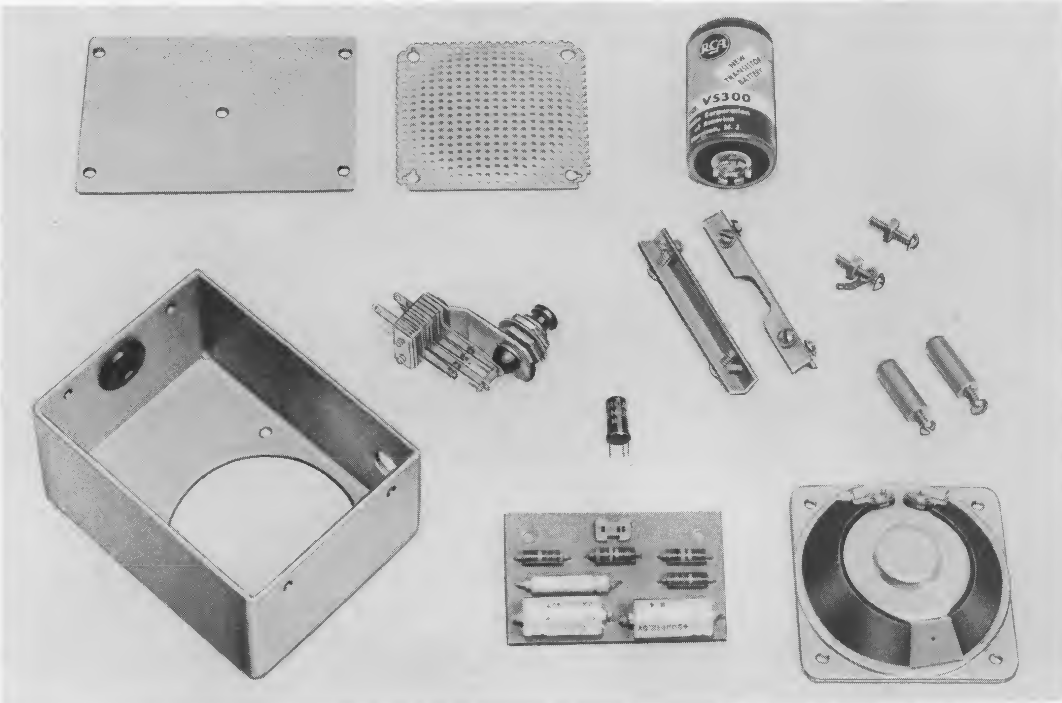
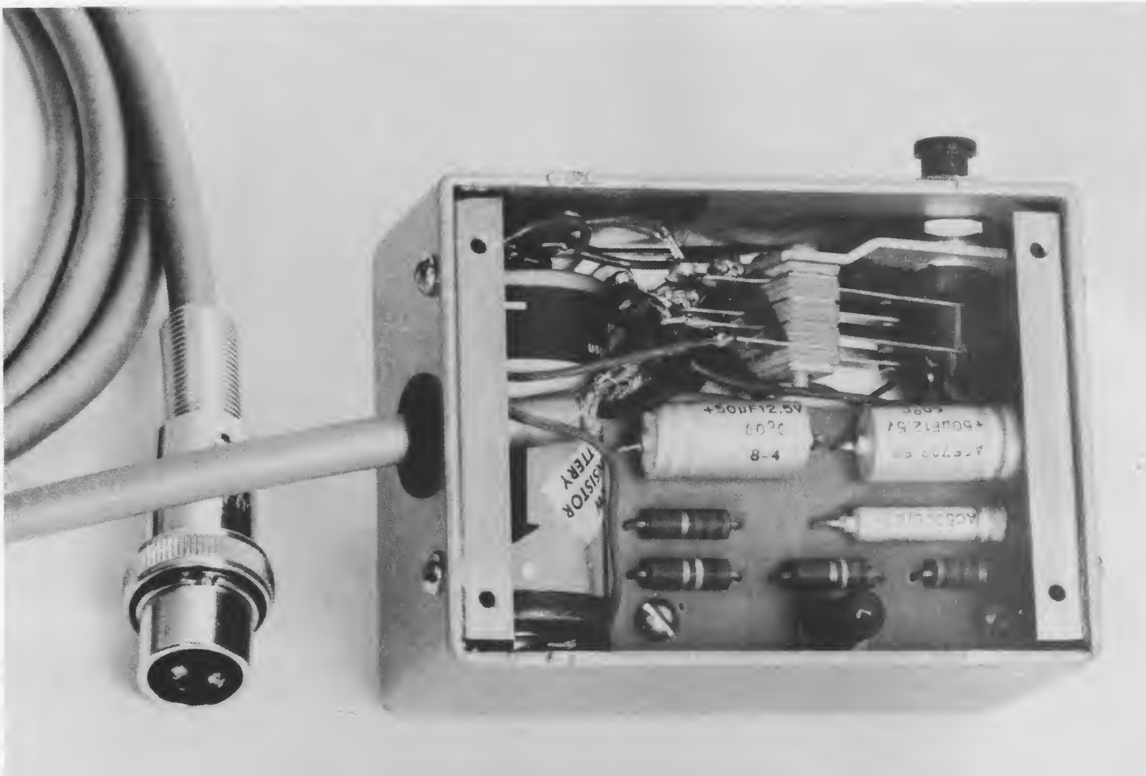


Figure 3: Microphone case with rear cover removed. The terminal board also holds the transistor battery in place.



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New Technical Manual on RCA Transmitting Tubes

Every ham will want a copy of *RCA Transmitting Tubes,* a 256-page manual published by the RCA Tube Division. A companion to the famous *RCA Receiving Tube Manual RC-17,* this new transmitting tube manual contains up-to-date comprehensive and authoritative technical data on 112 types of power tubes — including every "ham type" power tube in the RCA line, as well as tubes with plate-input ratings up to 4 Kw. Included in the manual are maximum ratings, operating values, characteristic curves, outline drawings, and socket-connection diagrams.

This manual contains 16 circuit diagrams showing the use of RCA tubes in representative transmitting and industrial applications. These circuits include a VFO for 3.5-4.0 Mc; crystal oscillators for both fundamental and harmonic output; amplifiers for Class C Telegraphy Service and for Class C Plate-Modulated Service; modulators; an electronic bias supply; transmitters for operation at 2 meters, 10 meters, and 462 Mc; and oscillators for dielectric and induction heating.

Covering basic theory of power tubes and their application in an easy-to-understand style, *RCA Transmitting Tubes* also contains valuable information for hams on generic tube types; tube installation and application; rectifier circuits and filters; interpretation of tube data; and the step-by-step design of af power amplifiers and modulators, rf power amplifiers, frequency multipliers, and oscillators. Simple calculations are given for determining proper operating conditions for tubes in class C telegraphy service, plate-modulated class C telephony service, frequency multipliers, and class AB and class B af amplifiers.

Rapid selection of an RCA power tube or rectifier tube for a specific application is facilitated by a series of five classification charts immediately preceding the tube-data section in the new manual.

A reference work that belongs in every ham shack, *RCA Transmitting Tubes* (Technical Manual TT4) may be obtained from your RCA tube distributor, or by sending $1.00 to Commercial Engineering, RCA Tube Division, 415 South 5th Street, Harrison, New Jersey.

HAM TIPS

RCA

A PUBLICATION OF THE RCA TUBE DIVISION

Vol. XVI, No. 4 December, 1956

VISUALIZING SWR

'SWR Circle' Clarifies Mistaken Theories

By Morton Eisenberg*, W3DYL

Most amateurs have a working knowledge of Standing Wave Ratio (SWR) and are aware that it is preferable to have minimum SWR on feeders so that power lost in the antenna feeder is kept to a minimum. However, this writer has heard numerous remarks on the air which indicate that many theories exist on the subject of how the SWR can be varied, including the erroneous idea that SWR can be varied by changing the length of the feeder.

To help clear the air of such misinformation, this article contains a graphical presentation of the relationship between the SWR on a transmission line and the length of the line. The presentation, usually referred to as the "SWR Circle," shows how the feed-point impedance can be found when the SWR and electrical length of the transmission line are known.

The SWR on the transmission line between the transmitter and the antenna coupler, "A" in Figure 1, can be varied by tuning and adjusting the coupler by inserting a device such as an impedance bridge in the "A" line. In this manner, a "flat" or nonresonant line (SWR = 1.0) can easily be realized.

The SWR circle applies to the "B"-line. coupler to antenna or, if no coupler is used, transmitter to antenna. Although optimum tuning of the transmitter and coupler assures that the maximum rf power is being transferred to the feeder terminals, it has no effect on the SWR.

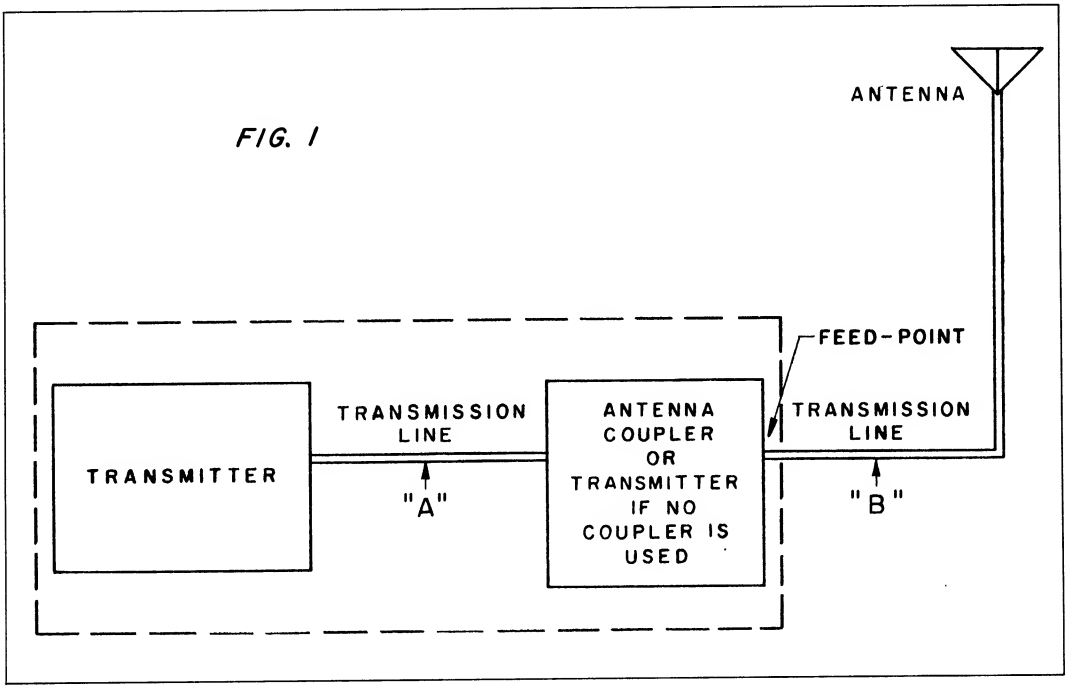
* Defense Electronic Products Division, Camden, N. J.

In Figure 2, the SWR circle is plotted for a 52-ohm cable. Similar SWR circles can be drawn for any other cable characteristic impedance and the procedure will be described later in this article.

Referring to Figure 2, suppose an SWR of 2:1 is measured on the "B"-line because a 52-ohm coaxial feeder is terminated by a 26-ohm resistive antenna impedance. Depending on the feeder length, the feed-point impedance could be 26 ohms resistive at Point X, 104 ohms resistive at Point Y, or any one of the infinite number of complex impedances, such as Point Z. Point Z represents a feed-point impedance of 65 ohms resistive in series with a 39-ohm inductive reactance. The convenient way to write this mathematically is: $65 + J39$.

Point X is the feed-point impedance which is found when there is no feeder, or when the feeder length is equal to a half-wavelength or any multiple of a half-wavelength. Point Y is the feed-point impedance when the feeder is equal to a quarter-wavelength or odd multiples of a quarter-wavelength. The feed-point impedance at Point Z is due to the feeder length being equal to one-eighth-wavelength.

It should now be clear that varying the length of the feeder cannot vary the SWR on the "B" line, nor can it vary the feeder losses per foot. When the feeder length is increased, simply "go around the SWR circle" in a clockwise direction. Remember that one full trip around the SWR Circle is equal to a half-wavelength of feeder.



The use of different feeder lengths to obtain variation in feed-point impedance is known to hams as "pruning the feeder to get the antenna to load." "Pruning the feeder" is sometimes necessary because of the limited impedance-matching capabilities of the coupling circuits. In this manner, a feed-point impedance which will more easily match the feeder to the transmitter (or coupler) can be obtained. *It is important to note* that although the feeder length has been changed, the SWR remains constant. You are simply going to another point on the SWR circle.

The SWR on transmission line "B" can be adjusted for minimum only by doing one of the following: (1) changing the transmitter frequency, (2) adjusting the length of the antenna element or elements, or (3) adding or adjusting a matching device at the junction of the antenna and the feeder.

Adjusting SWR for Receiver Feeders

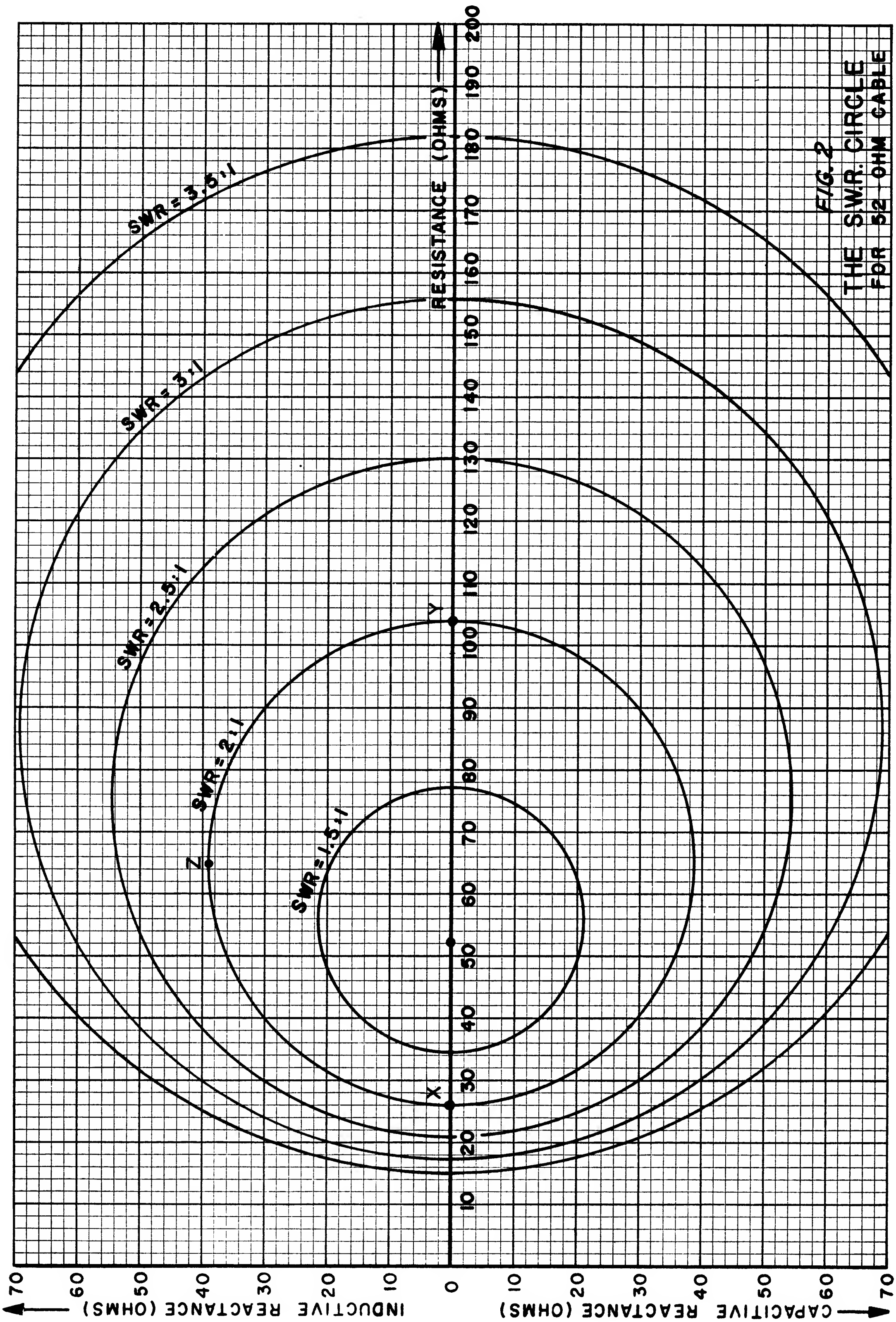
The SWR situation on the receiver feeder is slightly different from the problems arising in transmitter feeders. In this case, the SWR is a result of a mismatch of the input impedance of the receiver and the characteristic impedance of the feeder. Consequently, the SWR can be adjusted to 1.0 by the use of a coupler at the input terminals of the receiver. This coupler is only necessary, of course, if the input impedance of the receiver is not equal to the characteristic impedance of the feeder.

Other SWR Circles

For various cable characteristic impedances, SWR circles can be drawn by the procedure in the following example:

To draw a circle where the SWR = 3:1, with a 300-ohm line, the circle would cut the 100-ohm point $\left(\frac{300}{3} = 100\right)$ and the 900-ohm point (300 x 3 = 900) on the horizontal axis. The center to be used for the compass would be $\frac{900 + 100}{2} = 500$. Setting the compass to a distance equivalent to $\frac{900 - 100}{2} = 400$ units, with 500 as the center, will complete the job.

The SWR circle is an extremely simple method of visualizing the effect of an antenna-to-line mismatch on the feed-point impedance. It is also an easy, more understandable way of showing that varying the feeder length is a futile way to minimize losses. The SWR (or the loss) remains unchanged. To accomplish a change in SWR (or to eliminate a line loss) for any specific frequency would require a climb up to your "sky-piece."


RESISTANCE (OHMS)
INDUCTIVE REACTANCE (OHMS)
CAPACITIVE REACTANCE (OHMS)
SWR = 3.5:1
SWR = 3:1
SWR = 2.5:1
SWR = 2:1
SWR = 1.5:1
X
Y
Z
FIG. 2
THE S.W.R. CIRCLE
FOR 52 OHM CABLE

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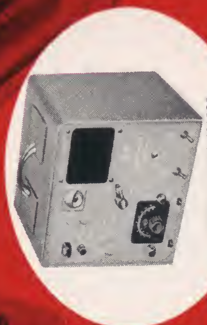

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HAM TIPS

A PUBLICATION OF THE RCA TUBE DIVISION

Vol. XVII, No. 1 February, 1957

AUTOMATIC CONELRAD ALARM

Provides Constant Guard for Conelrad 'Alert'

by G. D. Hanchett, W2YM

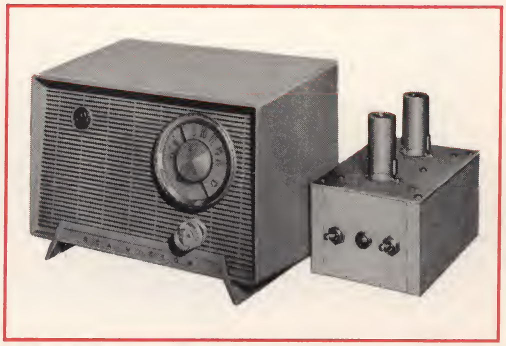
RCA Tube Division, Harrison, N. J.

The recent rulings by the Federal Communications Commission on Conelrad provide an excellent opportunity for amateurs who are interested in practical gadgetry. The writer, being one of those practical gadgeteers, and desiring to comply with the recent FCC ruling, constructed the automatic Conelrad alarm unit described in this article. This alarm unit can be used with any of the popularly-priced, five-tube, ac-dc broadcast receivers. Only one minor modification of the receiver is required, and this modification in no way affects its utility as a home receiver.

This Conelrad alarm unit does not require the use of relays. In addition, it emits a sound which is distinctive—there can be no mistake when the Conelrad "Radio Alert" is in effect.

The alarm unit consists of an oscillator of approximately 400 cps, which is keyed by a multivibrator at about 1 pulse per second. The multivibrator is controlled by a dc amplifier operated by the automatic-volume-control voltage of the broadcast receiver. Heater power is obtained from a miniature 6.3-volt, 1.0-ampere transformer. The "B" voltage (120 volts minimum, 250 volts maximum) is borrowed from the receiver.

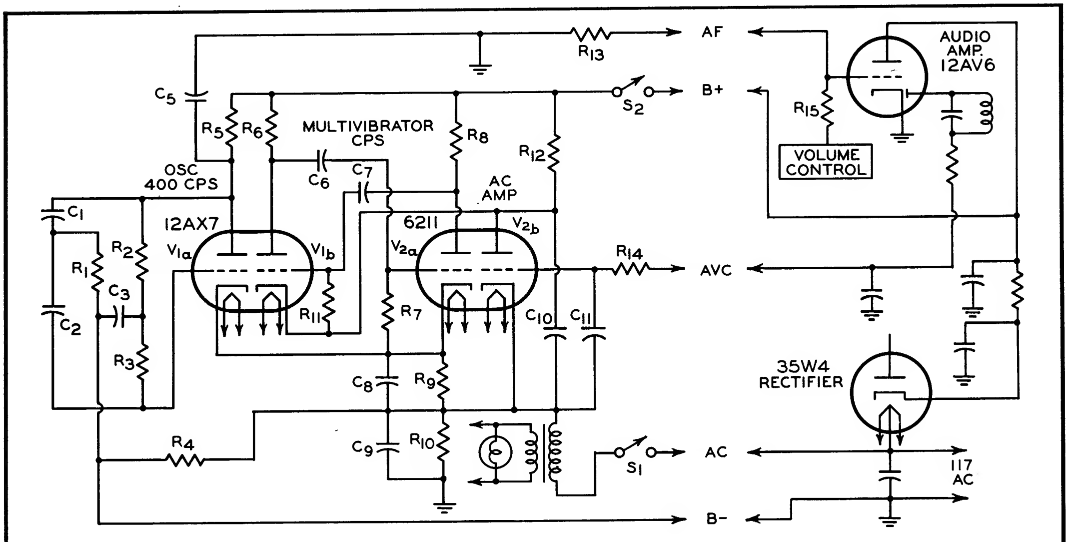
When the receiver is tuned to a broadcast station which provides 4 volts or more of avc voltage, the multivibrator triode section (V_{1b}) in series with the dc amplifier is held non-conducting. The second triode section (V_{2a}) of the multivibrator, consequently conducts continuously. Because the cathode resistor of the second triode of the multivibrator is in common with the cathode of the audio oscillator triode section (V_{1a}), the voltage drop across the cathode resistor is sufficient to cut off the audio oscillator and no audio tone is generated.



The automatic Conelrad alarm unit shown with the RCA model 6X5 series broadcast receiver. All components, except those visible in this view, are mounted on the underside of the cover plate.

When the Conelrad "Alert" is in effect, or when the broadcast station's carrier leaves the air and there is no avc voltage, the dc amplifier starts to conduct and sets the multivibrator into oscillation.

The multivibrator RC constants were picked so that it will oscillate at approximately one cycle per second. Therefore, the audio oscillator is keyed "on" and "off" at this rate. The output of the oscillator is connected to the control grid of the audio amplifier of the receiver and a series of "beeps" is emitted.



Parts list:

C_1—0.001 µf
C_2—0.001 µf
C_3—0.002 µf
C_4—0.01 µf
C_5—0.001 µf
C_6—0.25 µf
C_7—0.25 µf
C_8—0.25 µf
C_9—0.05 µf
C_{10}—0.1 µf
C_{11}—0.01 µf
L—indicator lamp, 6.3 volts, RCA-40
R_1—68,000 ohms
R_2—680,000 ohms
R_3—680,000 ohms
R_4—2.2 megohms
R_5—220,000 ohms
R_6—47,000 ohms
R_7—3.3 megohms
R_8—47,000 ohms
R_9—4,700 ohms
R_{10}—270,000 ohms
R_{11}—1 megohm
R_{12}—68,000 ohms
R_{13}—500,000 ohms
R_{14}—1 megohm
R_{15}—500,000 ohms
S_1—heater voltage switch
S_2—plate voltage switch
T—miniature transformer, 6.3 volts, 1.0 ampere
V_{1a}—, V_{1b}— RCA-12AX7 (½ audio oscillator, ½ multivibrator)
V_{2a}—, V_{2b}— RCA-6211 (½ multivibrator, ½ dc amplifier)

Schematic and parts list for automatic Conelrad unit.

Construction

Any broadcast receiver which will produce at least 4 volts avc can be used. The author used the popular RCA model 6X5C radio. This receiver is a 5-tube, ac-dc set which utilizes printed-wiring manufacturing techniques. Conversion is extremely simple.

The grid lead to the first audio amplifier, 12AV6, should be opened and a 500,000-ohm resistor (R_{15}) inserted, across which the audio output from the oscillator is impressed. This resistor permits the Conelrad alarm to operate regardless of the position of the volume control. Aside from this resistor and the external connections, no other alterations are required.

For convenience, an octal socket is placed in the center of the back of the receiver. This socket is used for connecting or disconnecting the Conelrad alarm unit without affecting normal operation of the receiver.

Wires from the ac, avc, B+, B— and grid of the first audio amplifier are connected to this socket. Shielded wires are, of course, used for all audio connections.

One triode section of a 12AX7 (V_{1a}) is used as the audio oscillator, while the other section of the 12AX7 (V_{1b}), together with one section of a 6211 (V_{2a}) is used as the multivibrator. The remaining section of the 6211 (V_{2b}) is used as the dc amplifier.

This tube arrangement was chosen because the audio oscillator needed a high-mu tube, and the dc amplifier needed a tube which has good control for cutoff characteristics. The 6211 was chosen because it is a twin triode especially designed for accurate "on-off" control of signals in applications such as electronic computers. Its grid cutoff characteristics are accurately controlled in manufacture. A 12AU7 could also be used in this socket, but the 6211 is designed to provide considerably superior performance in applications of this kind which may involve long periods of operation under cutoff conditions.

The alarm unit is constructed on a piece of aluminum 4″x6″, and mounted on a 4″x6″x 3″ chassis. All tube parts and components are attached to the cover with the exception of the control switches and pilot light.

The right-hand switch (S_1) turns on the heaters of the alarm unit, while the left-hand switch (S_2) controls the plate voltage. The heater switch enables the operator to activate the Conelrad alarm unit whenever he desires. The plate voltage switch is provided to eliminate the annoyance of an audible alarm signal as the receiver is tuned between stations. This feature is especially useful when it is desirable to have the alarm ready for instant use after tuning in a different station.

Since nearly all plastic-case, ac-dc sets have "hot-chassis" construction, a 0.05 μf capacitor (C_5) and a 270,000-ohm resistor (R_{10}) are connected between the B— and the metal chassis to eliminate the possibility of shock. If a transformer-type radio receiver is used, these components can be omitted and the B— can be connected directly to the metal chassis.

The components (R_1, R_2, R_3, R_4, C_1, C_2, and C_3) of the "T bridge" audio oscillator were selected to produce a frequency of approximately 400 cycles. Other frequencies can be obtained by increasing or decreasing the values of the resistors or the capacitors. Increasing the values of both types of components or decreasing these values, respectively decreases or increases the frequency.

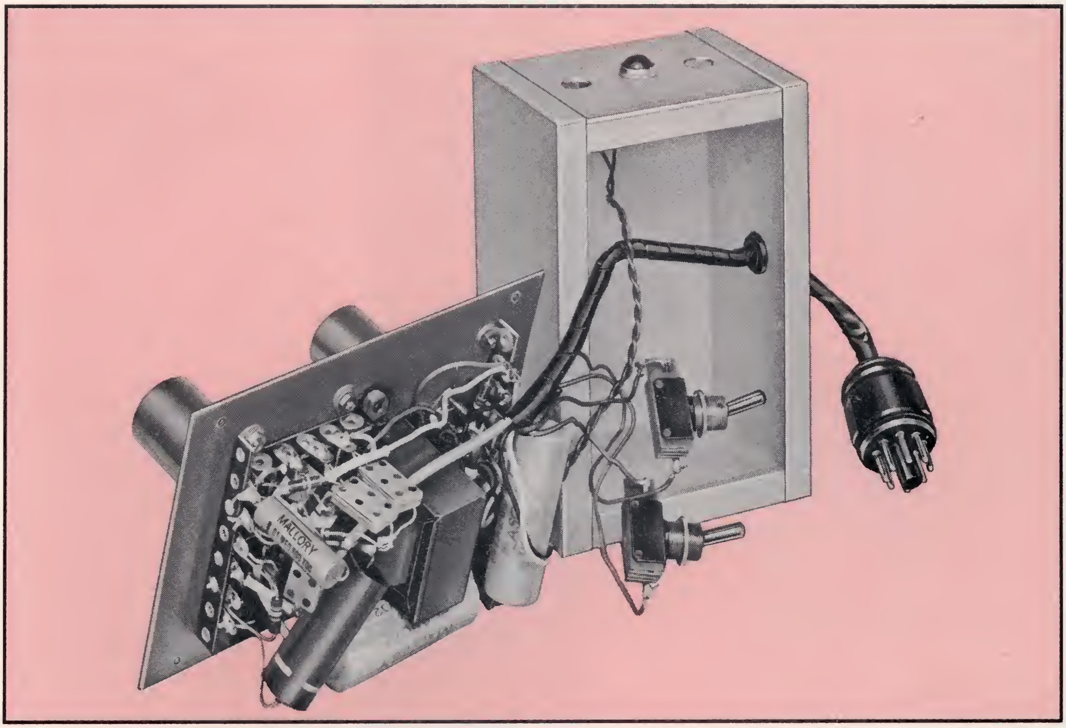
The rate at which these 400-cycle "beeps" will be produced is controlled by the time constant of the multivibrator (R_{11} C_7 and R_7 C_6). Again, increasing or decreasing the RC time constant will, respectively, decrease or increase the repetition rate.

A 68,000-ohm resistor (R_{12}) across that section of the 12AX7 used as a multivibrator insures that leakage currents from the 6211 will not start the system in operation.

This all-electronic, automatic Conelrad alarm unit fully satisfies the recent ruling (Docket 11488) of the Federal Communications Commission. It is simple, inexpensive, and easy to construct.

New Mike Box

The "make-your-own microphone" article by G. D. Hanchett, appearing in the September, 1956, issue of HAM TIPS (Vol. XVI, No. 3) described the construction of an aluminum box for housing the microphone. Bud Radio, Inc., manufactures a box which is ideally suited to the requirements of the transistorized microphone. Measuring 4″ x 2¼″ x 2¼″, the box is available in gray (CU-2103) or etched (CU-3003) finish. Using this box, the base response of the microphone will be slightly higher than that described in the original article.



Placement of components under the cover plate. Note position of transformer. Resistors and capacitors are mounted on three terminal strips as shown.

Beam Power RCA-6146. 90 watts input, CW: 67.5 watts on 'phone. Full input to 60 Mc.

Close-up view of the MB-560-A final, using an RCA-6146

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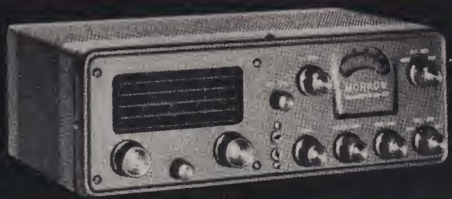

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HAM TIPS

A PUBLICATION OF THE RCA TUBE DIVISION

Vol. XVII, No. 2 April, 1957

RCA PUBLICATIONS FOR HAMS

New Transmitting Tube Manual Now Available

More and more hams are expressing unprecedented interest in the new 256-page RCA Transmitting Tubes (TT-4) manual. The new manual offers comprehensive and authoritative technical descriptions of 108 types of power tubes having plate-input ratings up to 4 kilowatts and 13 types of associated rectifier tubes. Maximum ratings, operating values, characteristic curves, outline drawings, and socket connection diagrams are also featured.

Covering basic theory of power tubes and their applications and written in an easy-to-understand style, the TT-4 manual contains information on generic tube types; tube parts and materials; tube installation and application; rectifier circuits and filters; interpretation of tube data; and the step-by-step design of af power amplifiers and modulators, rf power amplifiers, frequency multipliers, and oscillators. Simple calculations are given for determining operating conditions for class C telegraphy service, plate-modulated class C telephony service, frequency multipliers, and class AB and class B af amplifiers.

Rapid selection of an RCA power tube or rectifier tube for a specific application is facilitated by references to a series of five classification charts.

The TT-4 manual contains 16 circuit diagrams showing the use of RCA tubes. These circuits include a VFO for 3.5-4.0 Mc; crystal oscillators for both fundamental and harmonic output; amplifiers for class C telegraphy service and for class C plate-modulated service; modulators; an electronic bias supply; transmitters for operation at 2 meters, 10 meters, and 462 Mc; and others.

The manual, RCA Transmitting Tubes (TT-4), can be obtained from your local RCA tube distributor, or by sending $1.00 to Commercial Engineering, RCA, 415 S. 5th St., Harrison, N. J.

* * *

The capsule descriptions below point up the features of other technical manuals which radio amateurs are finding particularly useful in their hobby. Copies of these publications also can be obtained from your local RCA tube distributor, or directly from RCA Commercial Engineering.

* * *

RCA Receiving Tube manual (RC-18) is an up-to-date, 352-page book containing technical data on more than 575 receiving tubes. The book covers electron tube theory and applications, and is written in an easy-to-understand style. Other sections of the book include information on generic tube types, interpretation of tube data, and electron-tube installation. The price of the RC-18 is 75¢.

* * *

RCA Receiving Tubes for AM, FM, and Television Broadcast booklet (1275-G) is a 28-page publication containing classification charts, characteristic charts, and base and envelope connection diagrams on more than 600 entertainment receiving tubes and picture tubes. Price: 25¢.

* * *

RCA Interchangeability Directory of Industrial-Type Electron Tubes (ID-1020A) is a 16-page booklet which lists more than 2,000 type designations from 26 different manu-

facturers, arranged in alphabetical-numerical sequence. The listing shows the RCA direct replacement tube type, or the similar tube type, when available. Price: 25¢.

Longer Life for Your 6146's and 866-A's

The RCA-6146 beam power tube and the RCA-866-A half-wave mercury-vapor rectifier tube continue to be increasingly popular among hams. A few do's (noted below) should help to considerably increase the already long life of these two types.

Do's for the 6146

- Hold heater voltage at 6.3 volts—at tube terminals.
- Provide for adequate ventilation around tube to prevent tube and circuit damage caused by overheating.
- Keep shiny shielding surfaces away from tube to prevent heat reflection back into tube.
- Design circuits around tube to use lowest possible value of resistance in grid circuit and screen circuit.
- In high frequency service, operate tube under load conditions such that maximum rated plate current flows at the plate voltage which will give maximum rated input.
- Have overload protection in plate and screen circuits to protect tube in the event of driver failure.
- See that plate shows no color when operated at full ratings (CCS or ICAS conditions).
- Reduce B+ or insert additional screen resistance when tuning under no-load conditions to prevent exceeding grid-No. 2 input rating.
- Maintain tuning and loading adjustments precisely so that tube will not be subjected to excessive overload. The 6146 is a high-gain, high-perveance tube and can be more easily overloaded through circuit misadjustments than older types not having such features.
- Use adequate grid drive, keeping within maximum grid-current and screen dissipation ratings of tube. Too little grid drive can cause high plate dissipation.
- Make connections to plate with flexible lead to prevent strain on cap seal.
- Operate 6146 within RCA ratings as shown in technical bulletin available on request from RCA Commercial Engineering, Harrison, N. J.

Do's for the 866-A

- Hold filament voltage at 2.5 volts—at tube terminals. (Safety note: Do not measure filament voltage with the high-voltage transformer turned "on.")
- Hold condensed-mercury temperature within minimum and maximum ratings (20° C to 80° C with maximum peak inverse anode voltage of 2.5 Kv; 20° C to 70° C with maximum peak inverse anode voltage of 5 Kv; 20° C to 60° C with maximum peak inverse anode voltage of 10 Kv). Condensed mercury temperature can be measured at the bottom of the glass envelope, close to the base, with a small thermometer attached to the glass with a minimum amount of putty. Recommended operational temperature: 40° ± 5° C.
- Heat filament fully before applying anode voltage (15 seconds under normal conditions).
- After transporting tube, do not apply anode voltage until mercury has been redistributed (by heating filament only for 30 minutes).
- After idle periods, raise anode voltage slowly to the normal operating value.
- Keep rf out of rectifier compartment.
- Operate tube within ratings as shown in the RCA Transmitting Tube Manual TT-4.

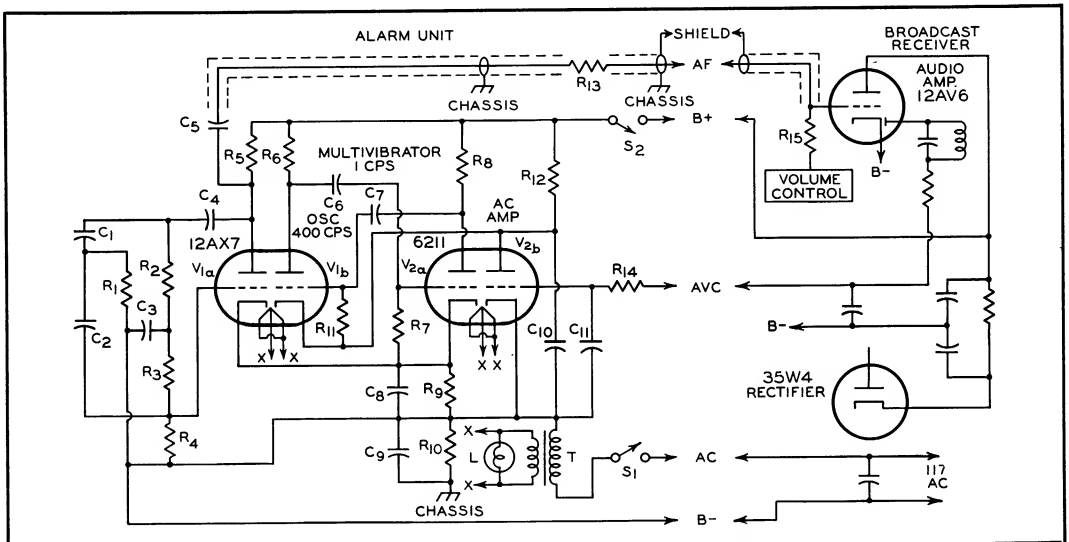
Back Issues of HAM TIPS Available

New amateur radio enthusiasts (we mean hams) and some of the oldtimers will be interested to learn that some of those recent back issues of HAM TIPS are still available. If you've missed any of the issues listed below, just drop a note to your technical editor, Bob Leedy, RCA HAM TIPS, 415 S. 5th St., Harrison, N. J., and we'll mail it with the compliments of your local RCA distributor.

Ham Band Charts (Vol. XVI, No. 1, March, 1956) was one of the most popular items ever to appear in this publication. This amateur-band frequency graph, showing useful data on the ham bands from 1.8 to 148 Mc, has been reprinted several times due to the many requests from hams.

Versatile Modulator (Vol. XVI, No. 2, July-August, 1956) by Peter Koustas, W2SGR, gave complete instructions for building a modulator providing any audio power between 25 and 100 watts and, therefore, can modulate 100% any rf input power up to 200 watts.

The Make-Your-Own Microphone (Vol. XVI, No. 3, September, 1956) by G. D. Hanchett, W2YM, describes a very popular transistorized microphone which has all the features desirable for mobile operation: good audio quality, fairly high signal output, insensitivity to unwanted electrical pickup, rugged construction and low price.



C_1, C_2, C_5—0.001 μf
C_3—0.002 μf
C_4, C_{11}—0.01 μf
C_6, C_7, C_8—0.25 μf
C_9—0.05 μf
C_{10}—0.1 μf
L—indicator lamp, 6.3 volts, RCA-40
R_1, R_{12}—68,000 ohms
R_2, R_3—680,000 ohms
R_4—2.2 megohms
R_5—220,000 ohms
R_6, R_8—47,000 ohms
R_7—3.3 megohms
R_9—4,700 ohms
R_{10}—270,000 ohms
R_{11}, R_{14}—1 megohm
R_{13}, R_{15}—500,000 ohms
S_1—heater voltage switch
S_2—plate voltage switch
T—miniature, transformer, 6.3 volts, 1.0 ampere
V_{1a}, V_{1b} RCA-12AX7 (½ audio oscillator, ½ multivibrator)
V_{2a}, V_{2b} RCA-6211 (½ multivibrator, ½ dc amplifier)

Schematic and parts list for automatic Conelrad unit.

Let's Face It!

Correction please: In the Automatic Conelrad Alarm article* which appeared in the February issue of HAM TIPS (Vol. XVII, No. 1), capacitor C_4 was included in the parts list, but was inadvertently omitted from the circuit schematic. The schematic should have shown the capacitor connected between the plate of V_{1a} and the junction of capacitor C_1 and resistor R_2. The corrected schematic is shown above.

The position of R_4 in the schematic was incorrect and has been changed as shown above. R_4 now connects to the grid of V_{1a} and to B—. The ground shown between C_5 and R_{13} on the af-output line is also in error. The output lead from C_5, through R_{13} and to the grid of the audio amplifier in the receiver, should be a shielded cable with the shield connected to the chassis of the alarm unit.

The 0.05-μf capacitor (C_9) and the 270,000-ohm resistor (R_{10}) should be shown connected between the B— and the metal chassis, not ground. In the text of the original article, capacitor C_9 was erroneously referred to as C_5. When a transformer-type radio receiver is used, C_9 and R_{10} can be omitted and the B— connected directly to the metal chassis.

Description: For the information of those readers who may not have acquired copies of the original article, the Conelrad Alarm unit can be used with any 5-tube ac-dc broadcast receiver producing at least 4 volts avc.

As shown in the diagram above, wires from the grid of the first audio amplifier, its shield, B+, avc, ac, and B— of the receiver are connected to the alarm unit. The "B" voltage can range from 120 volts minimum to 250 volts maximum. The author used the popular RCA model 6X5-series broadcast receiver and connected the Conelrad alarm unit to the receiver as shown in the right-hand portion of the schematic diagram. The only modification of the receiver required is the addition of a 500,000-ohm resistor (R_{15}) inserted between the grid lead of the receiver's first audio amplifier (12AV6) and the volume control.

When the Conelrad "alert" is in effect, or when the broadcast station's carrier leaves the air, the output of the alarm's audio oscillator will cause the receiver to emit a series of 400-cycle "beeps" at 1-second intervals.

***Automatic Conelrad Alarm by G. D. Hanchett, W2YM RCA Tube Division, Harrison, N. J.**

Close-up view of the RCA-807 final amplifier in the S-255.

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A TRANSISTORIZED QSO-GETTER

For 40-Meter QRP CW Operation

by E. M. Washburn, W2RG*

Many radio amateurs have expressed a keen interest in the amazing possibilities of low-power transistorized transmitters. This expressed interest has prompted the following description, so that others may join the growing ranks of QRP operators working hundreds—or even thousands—of miles on a fraction of one watt input.

The transistorized QRP transmitter illustrated and described in this article is essentially a 40-meter cw rig, using one RCA-2N140 transistor in the crystal oscillator and another in the amplifier. The transmitter is adequately powered by two 6-volt, heavy-duty dry batteries, connected in series, which are provided with a switch to permit tuning up at 6 volts. When the transmitter is operating at full load, the crystal oscillator operates at 12 volts with a collector current of 15 milliamperes, while the amplifier operates at 12 volts, 18 milliamperes. Admittedly, these inputs are *in excess* of the manufacturer's ratings and some transistors may not operate satisfactorily under these overload conditions. An RCA-VS069 1.5-volt dry cell is used in the oscillator emitter circuit as shown in the schematic diagram.

During the Spring and Fall of 1956, the author worked 18 states, Ontario, Quebec, Puerto Rico, Windward Islands and Transvaal, S. Afr.—all on 40 meters—with an antenna consisting of a single, 106-foot wire. The wire used with the author's transmitter is strung 28 feet across the basement rafters, then leaves the confines of the shack and slopes upwards for a distance of 42 feet to a flat top which is 36 feet long and 28 feet above the ground. The antenna can be voltage-fed from the amplifier or it can be fed from the antenna tuner.

Over a long period of operations, the signal reports received by the author have varied from RST-339 to 589, depending upon band conditions, distance and the type of receiver used by the receiving station. The QSO with Transvaal, S. Afr., (ZS6TR) appears to be a world record for a 40-meter low power/transistor transmitter and the contact was made without any form of prearrangement and without any previous communications using a higher-power rig. At 216 milliwatts and covering a distance of 8,000 miles, this performance is comparable to 37,000 miles per watt at a frequency of 7002 Kc.

Several contacts have been made on the 80-meter band, but the most gratifying and successful results have been accomplished in the 40-meter band. To the present, no attempt has been made to put the QRP transmitter on the 20-meter or the higher frequency bands; however, this band could be worked by using the amplifier as a doubler stage and substituting an RCA-2N247 transistor for the RCA-2N140.

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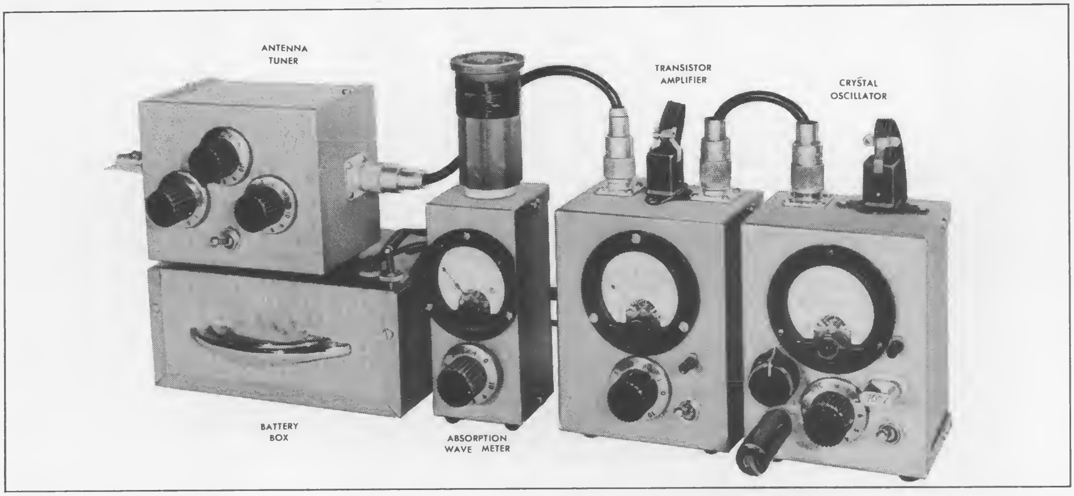


Complete transistor rig. Maximum input to the final amplifier: 216 Mw.

CONSTRUCTION

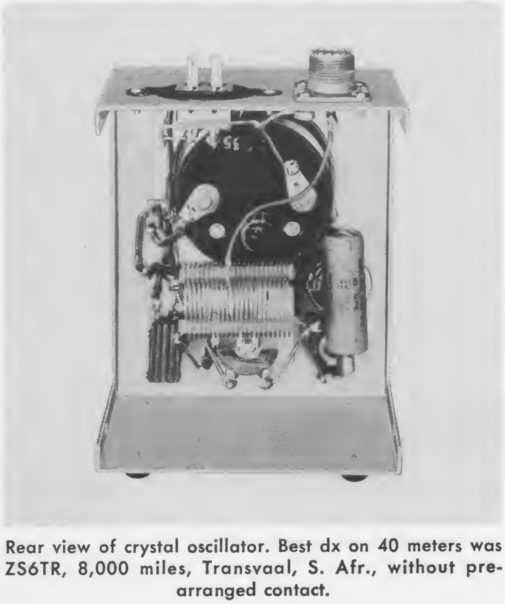
The complete transistor transmitter station comprises five units as shown in the photograph. The wave meter would normally be placed several feet away with its pickup coil about 2 inches from the antenna wire. Since this absorption wave meter is entirely conventional and the battery box is merely a housing for the two 6-volt dry batteries and the 1.5 volt dry cell, the circuit description will be limited to the crystal oscillator unit, amplifier and antenna tuner. Each of these three units is housed in a minibox which measures 5 inches by 4 inches by 3 inches. Interior construction details are shown in the photographs of each.

Although VFO circuits have been tried, the only successful operation has been with crystal control, and in this particular design the crystal unit is in the emitter circuit. The key is by-passed by a low-voltage 2 μf capacitor to improve keying characteristics, particularly when a "bug" is used. The most critical adjustment is the location of the output tap on the base inductor to achieve stable performance, free from "birdies."

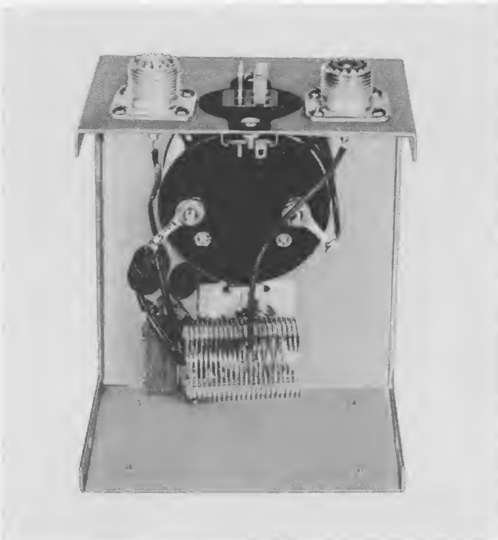
Whether or not an amplifier is used, the output tap on the tuned circuit inductor should be just far enough from the ground end for a stable signal, free from multivibrator type birdies when the key is first closed. In the unit described, the tap is almost at midpoint, 10½ turns from the ground end with a total of 23 turns in the coil. The optimum location for this tap must be obtained by "cut and try" method, keeping the collector voltage low and backing down on the emitter potentiometer to avoid exceeding 15 ma collector current.

The transistorized crystal oscillator is shown with the 2N140 transistor just above the crystal unit. The lower central knob adjusts the variable tuning capacitor, while the left-hand knob is used to set the "bias" potentiometer at optimum for clean keying at full output. The switch at the lower right is the main battery on-off switch, while the jack at the lower left is for the key. On top of the unit, the coax connector is for the rf output and the four-prong male connector is for the 12-volt and 1.5-volt supplies from the battery box. The inside components of the oscillator are shown in the photograph.

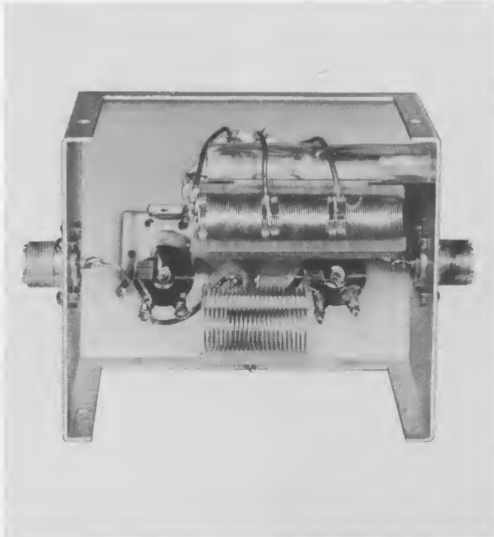
In the amplifier circuit, the only critical adjustment is the location of the tap on the



Rear view of crystal oscillator. Best dx on 40 meters was ZS6TR, 8,000 miles, Transvaal, S. Afr., without prearranged contact.

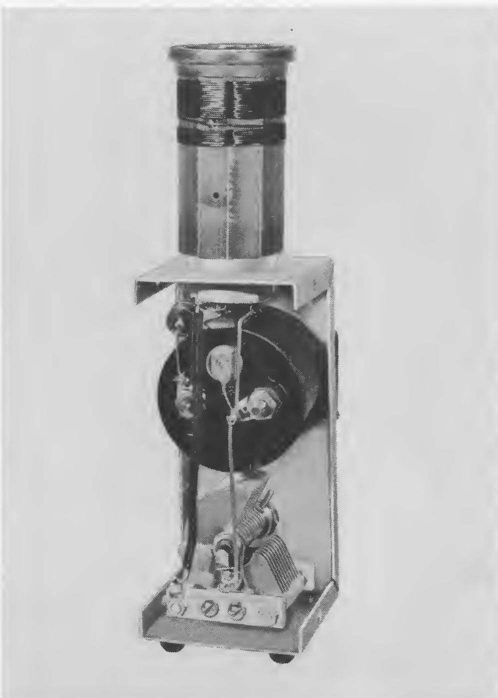


Rear view of transistor amplifier.



Interior view of antenna tuner.

collector tank coil. The optimum position must be found by trial, but should be near the midpoint or slightly towards the ground end. Because one set of batteries is used as the 12-volt supply for both the oscillator and amplifier, the on-off switch may be omitted since the common ground is made through the coax cable.



Construction details of absorption wave meter used to indicate maximum radiation from antenna.

The use of an antenna tuner was found helpful, although not essential. The absorption wave meter, however, is considered an absolute necessity, since it gives a sensitive indication of the radiated energy. During tuning operations, this meter pickup coil may be located close enough to the antenna wire (about 6 feet from the tuner or transmitter) to give a meter reading at about half-scale, assuming that full scale is about 200 μa. Then it should be removed completely or decoupled until the needle movement is just visible. Although the tuner circuit contains more components than absolutely required, it does permit precision tuning for optimum radiated power at minimum collector current, and in low power work of this particular type every individual milliwatt must be utilized to produce maximum power for maximum contacts.

As in conventional transmitter tuning, increasing the load will also increase the collector (plate) current, but instead of tuning the tank circuit for a dip in collector current, the more positive indication of proper loading is maximum wave meter current at minimum collector current. Maximum radiation normally will not be at maximum current in the collector circuit. Adjustment of the emitter potentiometer in the oscillator is quite critical for optimum setting.

In all tuning operations it is advisable to listen to the signal in the station receiver. As the voltage on the oscillator emitter is gradually increased and oscillation starts, the signal will sound very strong, even before there is

any indication of collector current in the amplifier. As the emitter potentiometer is advanced slowly, the oscillator collector current will increase and the keyed signal will become clean, with a slight ringing which is characteristic of crystal oscillator keying. Unfortunately, if there is any indication of radiated power under this setting of the potentiometer, it will be very small, and the emitter voltage should be further increased. At about 10 ma collector current, there should be a definite amplifier collector current and a wave meter indication of radiated power, and all tuning controls must be adjusted carefully until peak radiation is reached. During this final tuning, birdies are very liable to be heard in the receiver all over the dial, and tuning must be readjusted until the only signal heard is at the crystal frequency. If tuning alone is not effective in eliminating these spurious oscillations with a "cold" transistor, the emitter voltage in the oscillator must be reduced or the tap on its base coil moved further from the ground end.

When the keyed signal is clean and free from birdies, with collector current between 12 and 15 ma in the oscillator and 15 to 18 ma in the amplifier, and with a good indication of radiation in the absorption wave meter, that meter should be removed or coupled very loosely. The rig is then all set for normal use.

In at least one respect, however, operation will not be normal, and that is in establishing contacts. The only successful method experienced by the writer has been in answering general calls and rarely by calling CQ, CQ-TR, CQ-QRP, or any other form inviting a QSO. Experience teaches that it is well to listen for a few seconds before answering a CQ, to see if others are answering the same call. If so, it is almost a waste of time to answer, even assuming your crystal frequency is close enough to be hopeful of establishing contact. The writer has had best success by having a fair selection of crystals, choosing one which is in the least occupied portion of the band, tuning for optimum radiation at minimum power input, and waiting for someone to call CQ on that frequency. On 40 meters you don't have to wait long under normal conditions.

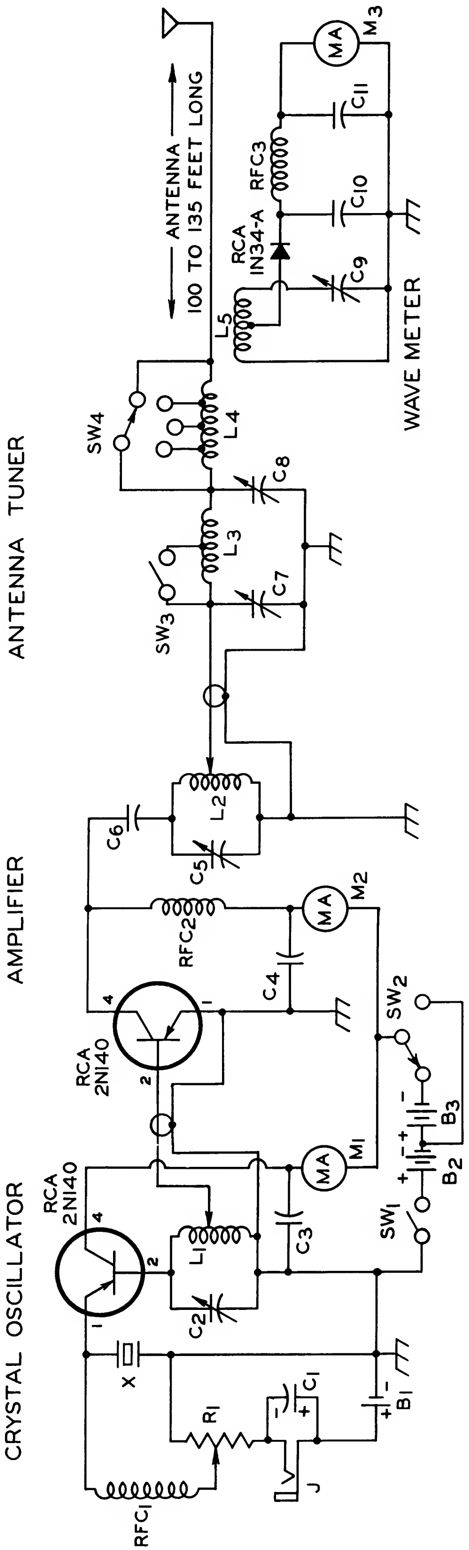
On 80 meters, a 2N139 may be used in place of the 2N140 and is slightly lower in price. Cutoff frequency of the 2N139 is approximately 5 Mc. The 2N140 should be used for 7 Mc operation, with its higher cutoff frequency at about 8 Mc. Future QRP rigs hold many possibilities of higher-frequency operation, voice modulation, and increased efficiency.

Your author wishes to emphasize the importance of selecting the proper location for the tap on the oscillator coil and also on the amplifier coil. Both are extremely critical *for optimum performance.* The antenna tuner described will load almost any kind of wire, but obviously the better antenna system employed, the better the results will be.

Your author has never used any form of beam and all contacts, nearly 200 at this writing, have been without previous arrangement and without previous contact with higher power equipment. In the author's opinion, such "piggy-back" contacts void the attraction of the adventure in transistorized QRP amateur communications.

PARTS LIST

B_1—Battery, 1.5-volt (RCA-VS069, or equivalent)
B_2—Battery, 6-volt (RCA-VS009, or equivalent)
B_3—Battery, 6-volt (RCA-VS009, or equivalent)
C_1—2 μf, electrolytic
C_2—0-100 $\mu\mu$f, variable
C_3—0.01 μf
C_4—0.01 μf
C_5—0-100 $\mu\mu$f, variable
C_6—0.001 μf
C_7—0-100 $\mu\mu$f, variable
C_8—0-100 $\mu\mu$f, variable
C_9—0-50 $\mu\mu$f, variable
C_{10}—0.001 μf
C_{11}—0.001 μf
L_1—23 turns B & W Miniductor #3015, tapped near center
L_2—23 turns B & W Miniductor #3015, tapped near center
L_3—23 turns B & W Miniductor #3015, tapped near center
L_4—2¾" length B & W Miniductor #3016, 3 equal taps
L_5—Any size 40-meter pickup coil center-tapped, which tunes through band, with C_9
M_1—0-20 dc milliameter
M_2—0-20 dc milliameter
M_3—0-100 microammeter
R_1—100,000 ohms
RFC_1—RF choke, 1 mh
RFC_2—RF choke, 1 mh
RFC_3—RF choke, 1 mh
SW_1—SPST switch
SW_2—SPDT switch
SW_3—SPST switch
SW_4—Switch, 4-position
X—Crystal, 3.5 or 7.0 Mc
RCA-2N140 Transistor (oscillator)
RCA-2N140 Transistor (amplifier)
RCA-1N34-A Semiconductor Diode (wave meter)



Grounds shown are to individual metal cases; no earth ground is used. Maximum collector input is 216 milliwatts to oscillator and also to amplifier. Batteries used should be heavy-duty dry cells.

40/80 METER TRANSISTOR TRANSMITTER

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